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Contents

SILICON CHIP

Vol.26, No.9; September 2013 www.siliconchip.com.au

Features

14 Speedometer Head-Up Displays
OBDII or GPS-based head-up displays (HUDs) can be purchased for around $100 and are far more accurate than your vehicle's own speedometer – by Leo Simpson & Nicholas Vinen

22 Graphene: 300 Times Stronger Than Steel
It's super-strong, super-thin and has a vast range of exciting applications in electronics and materials science – by Dr David Maddison

28 Review: Bush TR82DAB DAB+/FM/AM/LW Radio
This classic design looks almost identical to the original 1959 Bush transistor radio (described this month in Vintage Radio) but incorporates modern circuitry with FM and DAB+ reception – by Leo Simpson

82 Review: Altium Designer 2013 PCB Layout Software
Successor to the popular Autotrax and Protel ECAD programs, Altium Designer has a lot more features and capabilities than its predecessors. We take a look at the latest version – by Nicholas Vinen

Projects To Build

32 Speedo Corrector, Mk.3
If you've swapped your car's wheels, instrument panel, gearbox or differential, your speedometer may no longer be correct. This Speedo Corrector can fix that problem. It operates from 12V or 24V DC and is easy to build – by John Clarke

42 Collinear Antennas For Aircraft ADS-B Signals
Want to pick up aircraft ADS-B signals over a greater range than is possible using the antenna supplied with USB DVB-T dongles? These collinear antennas will do the job and can also be made for other frequencies – by Ross Tester

64 LifeSaver For Lithium & SLA Batteries
Don't ruin an expensive SLA, Li-Ion, Li-Po or LiFePO4 battery by over-discharging it. This small circuit will protect it by cutting off power before it reaches the danger zone – by Nicholas Vinen

70 Simple 12V/24V Regulator For 70V Solar Panels
Want to run 12V lights and accessories independently of the 230VAC mains supply? With a 72W solar panel, this simple regulator and a 12V SLA battery, you can run a string of LED lights anywhere and at any time – by Branco Justic

Special Columns

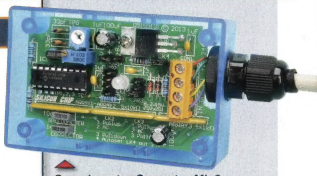
58 Serviceman's Log
Another day, another dropped phone or tablet – by Dave Thompson

78 Circuit Notebook
(1) MiniMaximite Version Of The 10-Channel Remote Control Receiver; (2) UV Light Box & Timer With LED Array; (3) Arduino Temperature & Humidity Data Logger

91 Vintage Radio
Best Of British: the Bush TR82C Mk.2 transistor radio – by Ian Batty

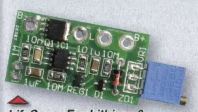
Departments

2 Publisher's Letter
4 Mailbag
27 Subscriptions
40 Product Showcase
96 Online Shop
98 Ask Silicon Chip
103 Market Centre
104 Notes & Errata

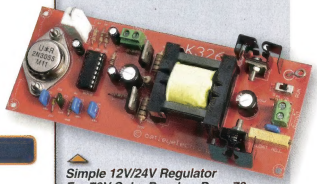


Speedometer Corrector Mk.3 – Page 32

Collinear Antennas For Aircraft ADS-B Signals – Page 42



LifeSaver For Lithium & SLA Batteries – Page 64.



Simple 12V/24V Regulator For 70V Solar Panels – Page 70.

SILICON CHIP
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SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $105.00 per year in Australia. For overseas rates, see our website or the subscriptions page in this issue.

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ISSN 1030-2662
Recommended and maximum price only.

Publisher's Letter

Head-up displays are a boon

This issue features an article on head-up displays in cars, starting on page 14. For a month or so now, I have been driving with a head-up display projected on to the windscreen, just below my normal view of the road ahead. Surprisingly, there is nothing particularly high-tech about the display itself. It is basically a 3-digit 7-segment multiplexed display which projects up onto a reflective layer on the windscreen. The display is actually mirrored vertically so that the image can be read.

I have reviewed two forms of the head-up display. The first is based on a GPS receiver (the same as in any GPS satellite navigation system) which simply displays the true vehicle speed. As such it has two significant advantages compared with my Honda Accord's own speedo: it is far more accurate and I don't have to glance down at the speedo to check it; I just slightly shift my gaze down a little, with my eyes never leaving the road ahead. It is such an effective system I have virtually stopped checking the speedo itself.

But there are drawbacks with the GPS head-up speedo display. Like all GPS units, it takes a while, maybe several minutes, before it first accesses the satellites and gives a meaningful reading. Second, it does not work in tunnels or in some inner city streets where tall buildings block the satellite signals.

Which is why I tried the second form of head-up display, based on signals from the car's OBD (on-board diagnostics) socket. This has a number of advantages over the GPS approach. First, it does not have a significant delay before it starts working and it is unaffected by tunnels, tall buildings or whatever. It is not quite as accurate as the GPS display but is considerably closer to the actual speed than the Honda's own speedo.

The OBD head-up display also shows a lot more information. As well as speed, it has a dramatic-looking bargraph tachometer and a smaller 2 or 3-digit display of the instantaneous fuel consumption in litres/100km. This really is a boon because it gives instant feedback about fuel consumption for even the slightest deflection of the accelerator pedal. Even more valuable, it tells you when your fuel consumption is zero! In my Honda Accord, this occurs at any speed above about 57km/h when my foot is off the accelerator and the transmission is in Drive.

This makes it far easier to drive with the utmost fuel economy in mind. It becomes something of a game – you try to use the minimum throttle setting at all times while keeping up with the traffic. At the same time, you develop the strategy of braking as little and as late as possible, driving very smoothly, anticipating changes of lights and traffic movements far ahead. All of this is necessary if you are to achieve excellent fuel consumption.

Now I know that most motorists don't drive with fuel economy in mind, even though fuel is expensive and ever rising in cost. If queried about this behaviour, they would no doubt argue, correctly as it happens, that fuel is not a major cost in typical car ownership. For my part, it is part of my normal driving behaviour to drive as economically as possible. I also happen to think that my passengers enjoy a very smooth trip better than one characterised by jack-rabbit starts, frequent braking and so on.

For anyone who is of like mind therefore, a head-up display with actual speed and instantaneous fuel consumption is most useful. And the great thing is that you don't have to change your car to get one. They can be purchased cheaply and they are simple to fit. Furthermore, if you drive long distances, driving with economy in mind can save a substantial amount in fuel cost over a year, as well as considerably reducing wear and tear on tyres, brakes, transmission and so on.

Leo Simpson

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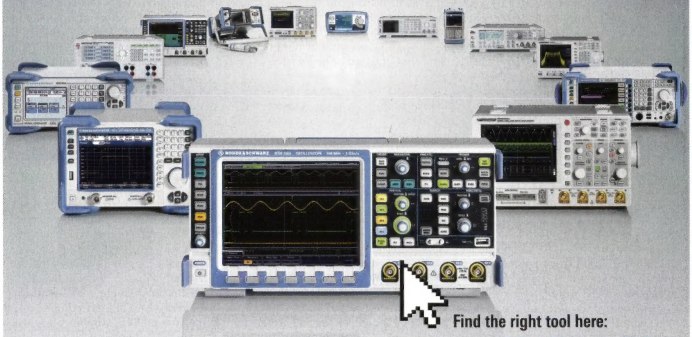

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Comment on the HMV 456A mantel radio

Although my 26-year spell in the radio design department of EMI at Homebush started in 1951, the photos of the 1946 HMV 456A mantel radio (made by this company) in the August 2013 issue, a slightly earlier radio, brought back some technical memories. For the last 12 years, from about 1965 to the closure of the Homebush plant in 1977, I was officially deemed "Senior Radio-Audio Development Engineer". It was my joy to work at my hobby, starting from the valve era to the solid-state era.

I have some comments on the photos of the radio. Notice that the tuning gang is on a rubber-mounted subassembly. Because of its proximity to the loudspeaker, this was an attempt to minimise acoustic feedback via the local oscillator tuning-gang plates.

Identical sections in the tuning-gang were used to track the local oscillator to exactly the tuned frequency plus the 457.5kHz intermediate frequency and there was a capacitor in series with the local oscillator gang and coil. When properly tuned with the aid of the oscillator coil and trimmer capacitors, there would be three positions on the dial at which the incoming signal and the local oscillator were "in step". Between those, the mild departure between the two could be plotted as an "S" curve.

Later, as radios became smaller, a smaller 2-gang tuning capacitor was manufactured by MSP, in which the local oscillator section had a smaller capacitance "contour" to ideally tune the two together. Also, the outer rotor plates were segmented to permit fine manually-adjusted tuning when doing the alignment.

Incidentally, a common practice to clean aged dirty plates was to connect the DC rail (approximately 200V) to the offending gang stator via a 1MΩ resistor. Fully rotating the gang a few times was often enough to 'burn-off' the dirt.

In developing a dial for a new model, a "standard" gang, with finely calibrated oscillator section, was used for plotting out every station's call-sign in Australia, by the drawing office, for the dial-glass manufacturer. Woe-betide any new model that failed to have them all! We'd soon hear of it from the "locals". The tuning gang rotation (in degrees) against signals from a calibrated signal generator was converted to dial-drum determined angular displacements for the draughtsman.

Eventually the 10kHz spacing of AM stations in Australia was changed to agree with the 9kHz European spacing. Station call-signs then disappeared. It

Nuclear power an interim power solution for Australia

If Australia is to maintain its high population industrial conurbations and phase out the now aging fossil-fuel power stations, it has no option but to go nuclear. Current renewable energy has shown some potential to take a greater role in powering non-industrial population centres and peak loads but not base load for heavy industrial centres.

Nuclear energy should be viewed as an interim measure for a 50-year period. This is about the life of a nuclear plant, giving time for development and systematic installation of renewable technology instead of the panic measures that have become a bandwagon for a quick buck that hides poor base load performance.

The only alternative to not going nuclear today is to accept rapidly lower living standards as the level of industrialisation is reduced under the effect of very high energy costs. Our energy hungry cities have grown up on the back of electrical power generation and adjustment will take a long time. It is not a question of putting in more and more wind turbines or solar panels; the physics and maths are just not that simple.

As someone who spent over 20 years with RF, X-ray, and nuclear radiation, I believe that all aspects of occupation health and safety for radiation is a non-issue, providing complacency does not set in.

Perhaps the most understandable and real fear from nuclear energy is that of accidents and disposal of used materials. It is mainly for the latter that I propose nuclear should be used as an interim fuel.

Good sites for the safe disposal of radioactive waste, although not rare, are usually located in places where social opposition is fierce, leaving only a few areas that are actually available. On-going use of nuclear will build up the waste mound and as the decay rate is so long, there does seem, with current technology, to be a limit as to how much waste we can reasonably cope with.

It would be silly to say accidents can never happen. Analysis of factors contributing to nuclear accidents do not seem to be just human/technical or equipment failure but have political, vested interest and corruption components that overruled technical reason. I have the confidence that Australia has a political and technical structure to eliminate these structural problems and ensure an incident is always contained.

Whether it is nuclear or fossil fuel, either way we still have to build new power stations and nuclear is the lower carbon option over the life span of the power station.

Kelvin Jones,
Kingston, Tas.

was interesting how long the numbers for both metres (wavelength) and kHz (then kilocycles/second) were retained!

The aerial coil was wound with Litz wire, in separate layers with "ferrite-like" slugs. These were pre-tuned, then dipped in pink wax. Whilst the selectivity of the radio depended primarily on the IF section, the aerial coil had a surprisingly high "Q", approaching 400, and also contributed to the selectivity. This was to the disadvantage of bandwidth and thus 'highs', particularly at the low (ABC) end of the dial.

With respect to the orange-coloured soldered joints in these sets, it was normal to position an inspector at the end of the assembly line with a pot of coloured lacquer and a multimeter. He/she would 'bless' the quality of each soldered joint with a dab of orange paint. Later in the life of the radio one would readily see what had been replaced by a serviceman. Other manufacturers used other colours.

With respect to the failed dial lamps and the open-circuited socket problem mentioned, we later switched to miniature bayonet sockets. Also, with the coming of solid state, I used a designated 6V dial lamp winding on the transformer for longer life (tests showed lamp life extended by the fourth power when the voltage was reduced!). My 43-year old HMV clock radio lamp still works!

Neville Snow, ASTCEE
Burwood, NSW.

Wrong valve used in vintage radio restoration

I enjoyed reading the Vintage Radio article on the HMV 456A in the August 2013 issue however there are problems using the 6F6 as an alternative output valve as described. The 6F6 and EL33 valves are not 'near equivalents'. While they are both output pentodes with 6V heaters and the same base configuration there are major differences in some of their other characteristics.

The 6F6 has a g_m (mutual conductance) of 2.5mA/V while the figure for the EL33 is 9mA/V. In simple terms, this means that the EL33 requires a much lower input signal to its control grid for the same power output.

Manufacturers were always looking for ways to save on component costs and because valves were a relatively costly item, if a receiver could be made with four valves instead of five the result was a more attractive selling price. Two popular configurations were used to try to make up for the loss of the fifth valve: (1) reflexing, where one of the remaining valves was used to amplify two signals at different frequencies and hence perform the function of two valves; and (2) the use of high-gain output valves.

Contrary to the text, the 6G8-G in the HMV does not function as an audio amplifier but only as an IF amplifier, detector and AVC rectifier since it is not reflexed. Hence the audio signal available to drive the output valve is relatively low and this is made up to some degree by the use of a high-gain output valve. With some component changes the 6F6 will function and on strong local stations, with the volume well advanced, the set will work but not with the overall performance attainable with the EL33.

Another significant difference between the 6F6 and EL33 is the required grid bias; -16.5V for the 6F6 and -6V

Mailbag: continued

Snowy hydro plants now off-limits to visitors

I recently visited the Snowy Mountains on holiday and I wanted to looked at some of the Hydroelectric Scheme infrastructure. I was very disappointed to learn at the Murray 1 Visitor Centre that there are now no public inspections of any of the hydro plants other than Murray 1 and then only for limited hours (although, to be fair, the Visitor's Centre is very good).

It used to be possible to do inspections of other hydro stations apart from this one.

I also went to the viewing area for the Murray II power station and saw evidence that there must have been explanatory signs at one time but these have been cut down; it looks like the support poles were cut off with an angle grinder. In addition, the viewing area at Eucumbene Dam was in poor condition.

The Snowy Mountains Scheme was and remains an extremely important engineering endeavour for Australia and continues to contribute to Australia's great wealth. It is a shame that it now appears to be less available for inspection than in the past.

School children used to learn about the Snowy Mountains Scheme and go on excursions to visit it. I certainly did. I suppose now they mainly learn about the supposed evils of building dams and using electricity . . .

Dr David Maddison,
Toorak, Vic.

for the EL33. This voltage is achieved by cathode bias in the HMV set via a 150Ω resistor (R14), in the cathode circuit of the EL3NG. If a 6F6 is to be used this resistor will need to be increased to 410Ω or the valve will be under-biased and draw excessive current, resulting in an overload of the HT supply, in turn placing a strain on the 6F6, output transformer, speaker field winding, rectifier and finally the power transformer. In due course, one of them will fail.

Better alternatives to the EL33 may have been the 6AG6 or KT61 which have similar characteristics however these are now getting harder to obtain. The function of the EL33 was provided in later years, with the advent of miniature valves, by the 6M5 which had almost identical characteristics.

Expecting any of the paper or electrolytic capacitors to be serviceable after 67 years is wishful thinking. Even if the electrolytics have not fully dried out their ESR will be 'through the roof' and though they may appear to be working will most certainly fail, sometimes in a spectacular way.

It was quite normal for the paper capacitors used in this type of set to need replacing during the normal working life of a receiver. The paper dielectric absorbs moisture and the attendant leakage results in a variety of faults in the set.

These days, the only place for old paper capacitors is in the bin along with the electrolytics!

Warwick Woods,
Glen Iris, Vic.

Lack of precision about motor currents

I read with a slight degree of alarm when someone states a running current and a starting current for an AC motor or an appliance with an AC motor. The running current is fine as it is generally a full-load current or a current draw under normal operating conditions. It is a value that is generally averaged out over a period that includes several or more AC cycles. Therefore, it can be measured with a clamp-meter or a shunt with a voltmeter.

The meter can be analog or digital, true RMS or an averaging meter calibrated to read RMS (assuming a sinusoidal waveform).

A starting current without explanation is less precise. Is it the peak measurement from a 100MHz or greater bandwidth CRO? Is it the perceived maximum swing of an analog meter that is actually measuring an average value and trying to display it as an RMS value, assuming the waveform is sinusoidal, which it wouldn't be? Is it the display of a digital RMS meter with max. hold capability? But we don't know the limitations of its measurement system in regard to dV/dt or maximum frequency response or perhaps one of dozens of other instrument measuring systems, each with its own little quirks.

Numbers quoted for ratios of starting currents to full-load currents vary from 3, 5, 7, 10 or any other number that someone thinks sounds good but rarely is the measurement procedure fully explained. The procedure should quote specifications like the actual instrument or class of instrument used for measuring the current, type of load at start-up, eg, lightly loaded (eg, fan), fully loaded at start-up (eg, hoist) or greater than 100% load at start-up (eg, conveyor belt).

The period should be specified over which the result is averaged, eg, 10 cycles, one cycle, one half-cycle, milliseconds and so should the method of averaging, eg, mean, RMS, instrument inertia, digital filtering.

Other factors are power supply source impedance (since the results using an infinite bus like mains power would be different to a portable generator or an DC/AC inverter) and AC power supply voltage and acceptable variations in that voltage. Motors can be rated at a nominal voltage but a voltage variation as small as 10% can make a big difference to the measured results.

Perhaps when contributors to this column or other articles state transient values like starting currents of motors they could include more details on how these values were obtained.

Trevor Krause,
Gympie, Qld.

Swapping tractor coil polarity

With reference to changing the ignition polarity of an old Ferguson tractor (Ask Silicon Chip, June 2013, page 90), it's even easier than the methods suggested therein. There are several ways to do it.

The easy way is to just flash the field terminal to +12V while the engine is not running. Then, before starting, lift of the D+ lead (dynamo + or output lead), start the tractor and rev it to 1500

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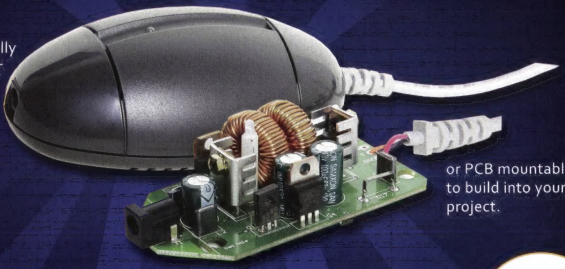

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Mailbag: continued

We should act now on nuclear power

I find your support for nuclear energy (Publisher's Letter, July 2013) refreshing. As I grow older, I am more and more convinced that Australia should move to nuclear power. We have the advantage of having much open space in which nuclear power stations could be built.

We should also be building solar power stations like the La Florida one at Alvarado in Spain. Using liquefied salt as a medium, it produces 432MW. We have the climate in which we should build several such plants across the country, thus providing some flexibility when cloud happens to reduce output from one of the plants.

We must act now to reduce our carbon emissions and going nuclear and building large solar plants is the way to achieve that end.

Ken Anderson,
Sale, Vic.

RPM. Check with your voltmeter that the D+ lead is actually positive with respect to earth. If it is, reconnect and away you go.

When reconnecting, watch the ammeter and listen to the voltage regulator. If the meter buzzes or the regulator makes a funny noise, it means that the voltage is still the wrong polarity and the voltage regulator is seeing over-current, switching off, seeing no current, switching on etc a hundred times a second. Obviously, the regulator contacts can't take that and will be quickly ruined.

If it does make funny noises, re-flash the field (DF) lead while the engine is running. That should fix it. If you are really lazy, start the tractor up (with the battery connected negative earth), let it idle (the voltage regulator won't be picked up as the engine speed is too low) and flash the field as above.

Give the throttle a bit of a nudge, and watch the ammeter. You should see it rise slightly towards the positive as the voltage regulator picks up, then as you increase the revs, it should go through zero and go more negative, or discharge. (This is because the ammeter will need its terminals swapped around to read correctly as the current is flowing the opposite way to what it was as + earth).

Don't worry about the starter motor as it's a series motor and polarity independent, as are the lights, etc. The voltage regulator is also OK and polarity independent.

Be aware that there were some alternators that were positive earthed but the old Ferguson tractors all used a CAV type generator with ratings from 19 amps (C39) to 25 amps (C42). Parts are becoming hard to find but bearings, bushes and brushes are still available from the older auto electricians. Circuits exist for electronic voltage regulators.

I have only had one generator fail to respond as above and that was a Bosch unit. No matter what I did, the next time the truck was started, it would

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Mailbag: continued

Cable voltage drop is the problem

Regarding a question by R. S. in "Ask Silicon Chip" (page 99, August 2013) "Using The Soft Starter With A Fridge", I may have a simple remedy. I too encountered similar problems starting my fridge with a generator. It is a 550-litre Samsung with electronic controls and initially I attempted to run it during a black-out with a Honda EU10i (a 1kVA inverter type) generator through a standard 10-metre extension cord. The fridge refused to start, displaying similar symptoms to those R. S. wrote about.

Standard 10A extension cords typically use only 1mm^2 conductors which I found caused enough voltage drop, coupled with the generator's limitations, to prevent the fridge from starting.

I bought a "heavy duty" extension lead from the local hardware store with 10A fittings but "15A" cable which used 1.5mm^2 conductors. This made all the difference, as my little 1kVA generator could now easily start the fridge. I have since had a caravan inlet socket mounted in my shed which has about 40 metres of 6mm^2 cable connecting it to a generator change-over switch in my meter box so I can power things in the house during blackouts without mucking around with extension leads and boards.

I still use the same little 1kVA generator connected to this inlet socket via a custom-made short, heavy (2.5mm^2) lead and even though there is now more than 50m of cable between it and the first appliance, it can start (in this order) a 550-litre fridge, a 160-litre freezer, a 32-inch CRT TV and a large number of fluoro lights, all running together, which goes to show just how critical wire sizing can be. Considering this example, a 3kVA generator should easily start at least one fridge as long as the interconnecting lead has at least 1.5mm^2 conductors.

Just a note about safety; my generator is run inside the shed for noise and security reasons but the exhaust connects to a pipe mounted through the wall to vent the fumes outside.

Dale Sills,
Bunbury, WA.

excite as positive earth. Re-flash and it would work negative earth until the engine was stopped. Never did solve that one.

Theoretically, the coil should be swapped around but in our climate, it does not seem to matter. There are some good reasons for + earth to do with electron flow. A new coil probably won't hurt as the original is 50 years old by now. Add electronic ignition and you've brought it up to the 21st century.

I can't resist a comment or two regarding the Federal Government's recent very fast train study. First, make it fast (600km/h+) and make it a tourist attraction. It could use mag-lev (magnetic levitation) to get around noise problems and be built four metres above ground. This has many advantages, such as freedom from floods, no straying animals on the track, no need to resume land (just simple easements are needed). The best route can then be selected and it doesn't have to follow the existing way. It could be built from many directions at once, with the work spread all over the country to hundreds of fabrication shops.

Peter Laughton (VK2XAN),
Tabulam, NSW.

An operator's view of wind farms

I was a member of one of the original crews of operators of the Woolnorth Wind Farm in far north-west Tasmania. I have been a hydro-electric power station operator for many years and hold electrical trade and electrical engineering qualifications. Having read all of the articles and letters in Silicon Chip on the pros and cons of wind energy, I can no longer sit back without adding comment on some of the issues.

In almost two years of spending long hours living and working beside operating turbines, not once did any members of our crews experience any form of sickness, nor did we suffer ill-health effects or sleep deprivation from being in close proximity to spinning wind turbines. This is not a statement for or against wind farms, it is just a fact.

In the June 2013 issue of Silicon Chip, one correspondent writes, "Wind Factories don't result in one less scoop of coal being used to generate power." In any electrical grid system running at a set frequency (ie, 50Hz in Australia), the net load demand must exactly equal the net generating capacity for the frequency to be stable at 50Hz. Indeed, power companies must go to great lengths to ensure that the system frequency is as close as possible to this figure, normally within tenths of one hertz.

Too little generation or too great a load and the frequency falls; too much generation or too little amount of loading and the frequency will rise.

Remember that many electronic devices derive their timing reference from the mains frequency. Thus, your correspondent's above assertion ignores the fact that when wind turbines are operating, the equivalent amount of other forms of energy must be ramped downwards as a result of this extra generation input.

The net result is that less fuel is being used, no matter what type. In the state of Tasmania, wind farms lend themselves perfectly to coexisting with hydro-electric plant. When the wind blows, the amount of energy generated means that the equivalent amount of hydro generation is not required, allowing that water to be stored for later use.

Many mainland centres use hydro pumped-storage systems in conjunction with wind generation for this reason.

Your correspondent further states that "Wind factories at best operate at 17% capacity and take power from the grid the rest of the time". The figure of 17% may be true of some wind farms but it must be remembered that these units are designed to operate with wind speeds of between 3.5 metres per second and 25 metres per second

and will have varying output power accordingly.

If we look at a hydro-electric power plant such as Wilmot Power Station in Tasmania's north-west, it has a maximum rating of 32 megawatts. There are times in wet weather when the dam is on spill and the station generates 32 megawatts. However, there are many times when the station is shut down because the water has run out.

The fact is that any generator is designed to produce the energy output that gives you the best all-year-round performance with the fuel resource you have available. The point about being only 17% of capacity would therefore seem irrelevant, given that we are really interested in annual yields from a renewable resource.

This comment encouraged me to look at a snap-shot of the generation trend from Woolnorth's Bluff Point Wind Farm, which is metered at the 110kV output transformer. For no particular reason, I chose the first 14 days of generation from June 1 to June 14, 2012 and recorded the output power every hour for the 24-hour period. On June 1, the wind farm produced only 6.6% of its capacity in the 24-hour period. On June 6 it produced 33.2% and June 7, 58.5%.

On June 14, it produced 62.99% capacity. The average yield for the 14 days was 33.05%. This study took considerable time to complete and one day I will sit down and calculate the whole year's generation. I am absolutely confident that the figure of 17% is way short of the actual figure for Woolnorth.

Your correspondent is also correct when he states that, "they take power from the grid the rest of the time". It is true, however, that the amount of power taken from the grid when the turbines are stationary is an absolute pittance when compared to generating output. This small amount is necessary to power the protection and control equipment, plus a token amount for light and power.

Having looked at the year's trend of the Bluff Point section of the Woolnorth Wind-farm, which has a total of 37 x 1.75MW units for an installed capacity of 64.75MW, in the first 14 days of June 2012 (traditionally our non-windy time of year) the peak generation reached 52.87MW, whilst the minimum figure on the trend line showed a value at one point of -0.92MW when the turbines were all stationary. This figure also includes the complete loading for the control building at Bluff Point.

The fact that a small amount is consumed when the plant is not operating applies equally to any power station you care to mention, since they all need permanently-powered equipment to sustain normal "ready to start" operation.

His final assertion that we should all educate ourselves by viewing a website called www.stopthesethings.com/ cannot go unanswered. Does anyone really believe that a website with such a name would present balanced views?

In summary, since I do not live or work near wind farms these days I have nothing to gain by presenting an argument for or against wind power. I am only interested in facts and it would seem to me that these facts are being skewed to suit particular points of view.

Terry Ives,
Penguin, Tas.

Ultra-HD & digital radio not mentioned

My letter is about the article "Digital TV: Where To From Here?", by Alan Hughes in the June 2013 issue of SILICON CHIP. This article answered my question about the data bandwidth of DVB-T2, which turned out to be more than enough if all free-to-air channels went Ultra-HD in H.265 video compression. In the Digital Ready brochures issued in the mail in June 2011 in our area, there was no specific mention about MPEG4.

I have identified a possible Service Number (or Logical Channel Number) conflict (Service 24) between ABC News 24 and a possible upcoming dedicated channel called ABC4Kids. After the change to MPEG4, if there is space for ABC4Kids (Service 24), ABC News 24 should be renamed ABC News 24/7 (a better name of course!) and move to Service 247.

There was no mention in the article about digital radio in the VHF High

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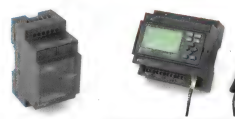
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Mailbag: continued

Petition to government concerning obsolete wireless microphones

With respect to the recent SILICON CHIP article (June 2013, pages 40-41) on new requirements for wireless microphones and my letter in the Mailbag pages of the August 2013 issue, the Australian Wireless Audio Group have started an electronic petition to be delivered to the Senate, asking for assistance to raise awareness of the issue and help get the department motivated in regards to a possible compensation scheme for community users.

The petition can be found at www.wirelessaudioaustralia.org/

Jeff MacKenzie,
Jands Pty Ltd (AWAG member).

band; VHF TV Channels 9 and 9A have notably been omitted from Restack Channel Block A, which means there are nine 1.5MHz wide DAB+ digital radio channels available with a gap before VHF Channel 10. Perhaps digital TV receivers could be "restack capable", which means you can scan for channels quickly in a single block which corresponds to your area?

Also, there was no mention in the article about Ultra-HD, despite mentioning about H.265 video compression. As you may know, H.265 has been ratified by the ITU for Ultra-HD transmission. In Australia, there are Ultra-HD TVs which may support H.265 video compression (may also support H.265 Ultra-HD) but the digital tuner may not be DVB-T2 capable.

It is essential that Ultra-HD terrestrial broadcasts use DVB-T2 and H.265 and that Ultra-HD receivers be capable of such. Such capability needs to be a prerequisite for an energy efficiency rating certification for Ultra-HD TVs. If H.265 video compression and DVB-T2 becomes an Australian standard, it needs to encompass Ultra-HD as well.

DVB-T2 and H.265 could mean that unused data bandwidth from commercial broadcasters could be used by terrestrial pay TV broadcasters and even wireless Internet services (downlink). I think HD channels going down to SD versions as per the article is a step in the wrong direction.

If VAST was to broadcast all channels in Ultra-HD, DVB-S3 (if it exists and is probably still in the works) and H.265 video compression would be essential.

Bryce Cherry,
via email.

Alan Hughes comments: a non-frame compatible stereoscopic (3-D) 4K Ultra TV (4096 x 2160 x 50p) has an uncompressed data rate of 6.6Gbit/s (Y, Pr, Pb) and using H.265 compression produces a data rate of 41Mbit/s, which is a full DVB-T2 Australian channel. I cannot see a TV station switching off their secondary channels when this program is transmitted. It would also mean that all receivers will have to be DVB-T2/H.265 capable so that those without a 4 K S3-D display will be able to watch the program. The only programs worth this treatment would be

the Melbourne Cup, AFL & NRL grand finals, the summer Olympics and the World Cup soccer final.

In March last year, http://beta.acma.gov.au/theACMA/ifc-32012-beyond-switchover-the-future-technical-evolution-of-digital-terrestrial-television-in-australia-acma-seeks-comment-on-technical-migration-issues-for-digital-terrestrial-television-broadcasting-dttb-services *discussed the introduction of MPEG-4 and DVB-T2 into Australia. Most submitters wanted to wait until the analog switch-off be completed prior to another change.*

Whilst LCN (logical channel number) 247 is allowable, viewers will not like three button pushes to select a program or they will select the program from a list. The easiest way is for the ABC to just change ABC24 to ABC News and any LCN starting with 2 can be used.

Currently, all digital receivers start scanning on channel 6 and finish at channel 69, with a jump from above channel 12 to recommence at channel 28. At the start of 2015, receiver manufacturers can stop the scanning past channel 51. Receivers made to Australian Standard AS4933 should only store and use the best signals from each network. This applies where there is a good signal from a local translator and a poorer signal from the main transmitter. The scan is only required once unless the receiver is moved to a different coverage area.

It will take around two years after ratification for commercial quantities of H.265 integrated circuits to be available to receiver manufacturers. The digital cinema (picture theatre) industry uses Ultra-HD which they call 4K. They are not using H.265 compression but a less aggressive compression.

Sony is selling 4K TVs but as with all the importers they don't tell you in the specifications what the tuner board is capable of. No projectors contain tuners, so a 4K capable set-top box will be required for 4K projectors and could be used for any TV.

On the question of whether H.265 video compression and DVB-T2 becomes an Australian standard, it will need to encompass Ultra-HD as well. This is unlikely to happen unless other countries do likewise. Currently, DVB-T2 is being tested in the USA with a maximum data rate of 35.85Mbit/s per 6 MHz channel. Unfortunately, S3-D (3840 x 2160 x 24p) produces an H.265 data rate of 37.3Mbit/s without sound, closed captions, audio description and synchronising data.

With respect to HD, you have misinterpreted what I have said. I want the HD channel to be the most popular programs, ie, the primary channel (eg ABC1, SBS1, Seven, Nine, etc). Unless transmission standards are changed, there will not be enough data available for a pair of HD channels, hence the existing HD channels except SBSHD will have to change to SD. If all programs are MPEG-4 compressed, then a pair of Full HD channels is possible provided statistical multiplexing continues to be used.

Finally, VAST is paid for by the Commonwealth Government to give viewers in remote areas and black spots a similar program choice as the rest of Australia using terrestrial TV. There is no such thing as DVB-S3 and it is not on the drawing board. SC

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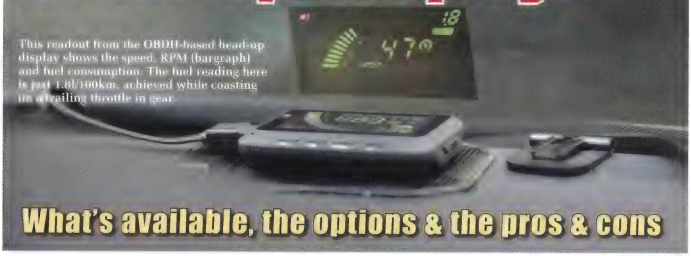

This readout from the OBDII-based head-up display shows the speed, RPM (bargraph) and fuel consumption. The fuel reading here is just 4.8l/100km, achieved while coasting in a trailing throttle in gear.

What's available, the options & the pros & cons

There is no need to buy the latest Commodore or an up-market European car in order to get a head-up digital display of your speedometer. For around $100 or less, you can purchase an OBD or GPS head-up display (HUD) which is easy to read and has the bonus of being far more accurate than your vehicle's own speedometer.

I HAVE SEEN the light and it is good. It is the digital image of my vehicle's speed, floating somewhere in front of my windscreen. I no longer have to avert my gaze from the road ahead to check my speed: something I need to do frequently to avoid the risk of being booked in Sydney's manifold speed zones.

Of course, while I want to avoid speed fines I also want to travel as fast as is legally possible in any speed zone. After all, why dawdle when you can dash? So if traffic and road conditions permit, I like to travel close to the legal speed limit. Trouble is, if you rely on your car's speedometer, you will almost always be travelling more slowly than you need to.

Why is that? Because under Australian Design Rules, modern car speedometers must never indicate more than the actual speed. But they can indicate the actual speed optimistically by a factor of 10% more plus 4km/h. So at an actual speed of 60km/h, the indicated speed could ostensibly be anywhere from 60km/h to 70km/h. Similarly, at 80km/h, the indicated speed could be anywhere from 80km/h to 92km/h and at 110km/h (the maximum legal speed in most states), the indicated speed can be anywhere up to 125km/h.

In practice, car speedometers are rarely so wildly optimistic but on my own 2004 Honda Accord, an actual speed of 100km/h gives an indicated reading of 107-108km/h. In these days of fancy car electronics, this really

This GPS head-up display was purchased on eBay for around $100 and can be powered via the supplied cable from either a USB interface (ie, in the car) or a 12V accessory socket.

The GPS head-up display in action. A piece of film attached to the windscreen reflects the speed readout on the LED displays. The reading here is 44km/h but note that the car's speedo shows more than this because (a) it's slightly optimistic (ie, reads higher than the true speed) and (b) because the angle of the photo has introduced some parallax error.

does seem silly, especially as odometers are typically much more accurate and appear to be within ±1% or 2%.

Of course, none of this is news to anyone who uses satellite navigation in their car. You can read your actual speed, along with a lot of other navigational information on the display. Many, if not most, smart phones now on sale also have in-built satellite navigation so there is no need to rely on your car's speedo when setting your cruise control; just run the car up to the legal speed as indicated on your GPS and hit the button to set the cruise control. Most other drivers on expressways now seem to do the same thing, as do long-distance truck drivers.

The problem with the speed reading on most GPS units, such as those made by Garmin, Tom-Tom and Navman etc, is that it is too tiny. You cannot just glance at it to see the speed. And while you're peering at the GPS, your attention is diverted from the road and when you look back up, you might be veering off into the incoming traffic! In the meantime, your passenger is liable to be seriously terrified!

Even if you do have GPS satellite navigation in your car, a GPS head-up speed display is even better. So recently, I purchased one from eBay but I have since discovered a local source advertising another GPS head-up display in the NRMA publication, the "Open Road" – see http://mypolaris.com.au/hud/indexflash.html

Both work on the same principle.

Option 1: GPS HUD

In essence, the GPS head-up display I purchased consists of a small plastic case with three green LED 7-segment displays. The unit is installed forward of the speedo binnacle on the dashboard and tilted up so that the reflected display is within your field of vision but not so high as to be distracting when you are looking at the road ahead. The LED displays are arranged back to front and reversed in order so that the reflection reads correctly.

The unit is powered from the car's cigarette lighter and that is a drawback because inevitably you have a long cable from the closest cigarette lighter or accessory socket to the unit up on the dash. The same comment applies to any after-market GPS sat-nav unit made by Tom-Tom, Garmin etc (unless you operate it from the internal battery).

To improve the reflectivity of the windscreen, a small piece of dark plastic is arranged to improve the contrast of the display. However, it is quite difficult to install it in precisely the right place in order for the reflected reading to be centred in the display. In my case, this is because it is a long way from my eyes to the plastic piece on the windscreen, about one metre, and my arms are simply not long enough to be able to carefully position the plastic piece while viewing it from the normal driving position.

The unit incorporates an LDR (light-dependent resistor) to sense ambient light levels and reduce the display brightness for night-time driving. Display visibility is quite adequate for driving at night and in overcast conditions but suffers somewhat in bright sunlight and especially if you are wearing polarised sunglasses.

In use, the display appears to update as often as about five times a second, depending on whether the car is accelerating or slowing down. How accurate is it? We don't really know but we think that it is within ±1% + 1 digit.

In practice, when you are maintaining a constant speed on a flat section of road, the reading fluctuates only very

The iFOUND head-up display unit is available for around $75 and is supplied with a cable which plugs into the vehicle's OBDII socket. As well as speed, RPM and fuel consumption, it also has the option of displaying coolant temperature or battery voltage (instead of the speed) at the touch of a button.

The readout on the dash-mounted head-up display unit is a mirror image so that is reads correctly when reflected off the darkened film attached to the windscreen (note: this unit is also shown updside down).

slightly, say from 99km/h to 100km/h, maybe several times a minute. It appears to fluctuate a lot more in hilly country but then it is much harder to maintain a constant speed.

The head-up display also reveals that when you have cruise control engaged, the speed does vary by quite a bit; more than you might think and that is apart from the normal over-speed that you get with cruise control when on a long down-hill slope.

Overall, the GPS head-up display is a worthwhile addition. I find that I only occasionally glance at the speedometer now, since the HUD is always there and it is much more accurate anyway.

However, there are drawbacks to the GPS HUD. First, when you first start up in the morning (or whenever), the GPS can take quite a while to 'acquire' the satellites and give a valid speed reading. During that time it just flashes three dashes on the digits. If there is heavy cloud cover, it can take up to five minutes to give a speed reading.

Second, GPS doesn't work at all in tunnels or in city streets where there are lots of tall buildings, so again all you get is three flashing dashes on the display. In the overall assessment of the total human condition, this is not a big problem but there is another way and that is to use an OBD-derived head-up display.

Option 2: OBDII HUD

So having purchased the GPS HUD above, I had a look on the internet for a HUD based on OBDII signals. Lo and behold, they are available and generally cheaper than the GPS-derived units, to boot.

I duly plunked for an iFOUND unit made by Founder Technology Group Co Ltd, in China and available on eBay for $75.69. This connects to the OBDII socket found in virtually all modern cars, typically positioned under the dash to the right of the steering wheel (ie, in right-hand drive cars; it's the opposite in left-hand drive cars).

You need to check whether your vehicle has an OBDII socket before you consider purchasing one of these head-up display units.

OBDII stands for "on-board diagnostics, version two" and is a now-standard vehicle interface designed primarily to allow mechanics to check and clear engine computer fault codes and monitor vehicle operation in real-time for fault-finding and tuning. The particular OBDII HUD I purchased decodes some of the data available on the OBD socket to display speed in km/h, fuel consumption in litres/100km and engine RPM. It also has the option of displaying coolant temperature or battery voltage instead of the vehicle's speed at the touch of a button.

However, the overall display is much more elaborate than the simple GPS-derived unit discussed above. Three large digits provide the speed readout (or battery voltage or coolant temperature) while three smaller digits above give the fuel consumption.

Engine RPM is displayed in a curved bargraph which changes from green to red at the top of the rev range. Plus there are a few other symbols for the alarm functions (speed, coolant and battery voltage), gear shift points etc. Again the display is inverted and transposed left to right, so that the windscreen reflection can be read.

The iFOUND unit comes in two parts: the HUD itself and a metre-long flat cable with a plug which you fit into the car's OBDII socket. The unit has a slide switch to turn it on or off and four buttons which you can use to change the display mode, set alarm levels and set gear shift points etc.

Installation is similar to the GPS HUD reviewed above. The HUD unit is positioned forward of the instrument binnacle and arranged to reflect off the windscreen. A piece of semi-transparent plastic is provide for this purpose (as with the GPS HUD). The cable connection is much more convenient and neater than the GPS unit because it effectively runs up from under the dash (near the steering wheel) and can be run between the door and the side of the instrument panel.

Again the OBD unit has an LDR to sense ambient light but in this case, while display brightness is adequate at night, it is anaemic in sunlight. As an aside, when driving at night I noticed that the display brightness was fluctuating and I finally twigged that the unit was dimming the display each time I passed underneath a bright street lamp. This is annoying, to say the least.

I fixed it by disabling the LDR. I disassembled the unit and measured the LDR in bright light and darkness. It varied between about 12kΩ in darkness to less than 4kΩ in bright light. I soldered a 4.7kΩ resistor across the LDR and now the brightness is constant. Possibly, it is slightly brighter than ideal at night-time but it's still too dim in bright sunlight.

Using it

At start-up, the OBDII-based unit initially displays 'HUD' and '101' and then briefly flashes the whole display, including the RPM bargraph. As soon as the car moves, it gives the speed and the fuel consumption which is very high initially but then drops to more reasonable figures as you build up speed.

I was able to compare speed readings from the GPS and OBD HUD units and the differences were interesting. The OBD unit seemed to update at about the same rate as the GPS unit and was generally within 1km/h. So if the OBD unit came up to 60km/h (say), the GPS unit would show 60 and then maybe flick to 61km/h. In other words, the OBD display is more accurate than the vehicle's speedometer but slightly pessimistic with respect to the GPS reading.

Driving with the iFOUND OBDII-based head-up display. The instantaneous fuel consumption readings give continuous feedback on your driving style and help you to save fuel.

At higher speeds, the units diverge more. At around 80-90km/h, the GPS reading was typically 2km/h higher than the OBD unit. At the time of writing, I had not driven on any of Sydney's toll-ways or freeways so I cannot comment on whether the trend worsens at higher speeds.

So while the OBDII HUD is more accurate than my vehicle's speedo, I will always have to allow for the discrepancy between it and the GPS reading in setting the cruise control. However, I came to the conclusion that the OBDII unit is probably even more useful because of its fuel consumption readings (my 2004 Honda Accord lacks this facility), since it gives you continuous feedback about your driving style.

If you step on the gas as you move away from the lights, the instantaneous fuel gulp can easily rise well above 45 litres/100km. Take it more easily and it might start at 12 litres/100km and then drop to less than 4 litres/100km as you gingerly caress the throttle to keep up with the traffic.

Better still, if you coast as much as possible on a trailing throttle (ie, foot off the pedal), the reading will drop to zero provided the speed is above about 50km/h (in my Honda Accord). This indicates injector cut-off and it is surprising just how far you can travel in normal traffic while not consuming any fuel at all. Such information is vital if you are concerned about reducing fuel consumption.

It confirms my habit of driving 'far ahead' to anticipate traffic hold-ups, red lights, lane blockages and so on. This and the continuous fuel reading can be very effective. It becomes a bit of a contest but I would never go so far as 'hyper-milers' who can obtain extreme results by coasting with the engine off for long distances, tail-gating trucks and buses and other driving behaviour which can be extremely hazardous.

Incidentally, when the car is stationary and the motor is idling, the fuel consumption reading changes to litres/hour and is typically 0.7 litres/hour when the engine has reached normal operating temperature.

So I regard the OBDII HUD as more useful than the GPS unit, even though I would like the display to be brighter. But there is a third way, and Nicholas Vinen takes up the story on the following page . . .

Option 3: using a smart phone & an OBDII-To-Bluetooth Adaptor

By NICHOLAS VINEN

If your car lacks a digital speedo, you can make up for it with a smart phone, an OBDII-to-Bluetooth adaptor and some free software. You can choose from a range of display options and arrange them on the screen to suit your tastes.

This third option involves using a smart phone. All you need is a low-cost OBDII-to-Bluetooth adaptor and a dashboard/windscreen mount for your phone – which you may already have anyway, if you use the GPS on your phone for navigation while driving.

It also gives you access to data from the engine and body computer such as speed, RPM, engine load, coolant temperature and battery voltage which can be displayed on the phone's screen.

In fact, if your phone has built-in GPS, you can get the vehicle speed and GPS speed side-by-side. On our test vehicle, we found that they matched very closely when in a constant-speed cruise on level ground; typically within less than 1km/h of each other. Note that while GPS speed is shown with one decimal place, the OBD-II speed appears to be rounded to the nearest integer.

Where to get the dongle

The required dongle (OBDII-to-Bluetooth) is inexpensive and is available from multiple sources via websites such as eBay and Ali Express. For example, we bought ours from "Shenzhen win-win Electronics Technology Co Ltd" for the princely sum of US$8.50 with free postage via China Post; see http://www.aliexpress.com/item/Latest-Version-V2-1-Super-Mini-ELM327-Bluetooth-OBD2-Scanner-ELM-327-Bluetooth-For-Multi-brands/808159089.html

Note that China Post can be slow; Hong Kong post is a faster and more reliable option, if available.

The OBD port is found under the dashboard, typically just to the right of the steering column (in a right-hand drive car). Power for the unit is derived directly from the OBD port.

A typical OBDII-to-Bluetooth adaptor. They're available via websites such as eBay and Ali Express for around $10. It plugs into the card's OBD port and you can pair it with a tablet or smart phone.

Mounting it

We used a goose-neck windscreen mount from Jaycar (Cat. HS9002) to place the phone right in the bottom corner of the windscreen. While this isn't quite as good as a HUD, it's certainly more convenient to glance at than a dash-mounted speedometer and you still have the benefit of a digital read-out which some people find much easier to interpret than a needle on a dial.

One problem is that virtually all smart phones have shiny screens and if driving in bright sunlight, reflections of the driver's shirt or objects behind the car can obscure the display. But despite this, the read-out generally remains legible under most lighting conditions and is especially good at night.

As well as the phone and the Blue-

This view shows a Samsung Galaxy Tab2 tablet paired with an OBDII-to-Bluetooth adaptor and running the free Torque Lite app from the Google Play Store. You can display a variety gauges and graphs in various forms using information derived from the OBD port.

tooth OBDII dongle, which plugs in under the dashboard (and is so small that you can hardly notice it's there), you need software running on the phone to communicate with the car and interpret and display the data (an "app").

We downloaded a free version of a program called "Torque Lite" (from Google Play) which works on most Android phones and tablets. iPhone/iPad users will have to use different software such as DashCommand, although this isn't free.

Torque Lite works reasonably well although it has a few bugs and it drains the phone's battery pretty quickly when in use. That's partly due to the fact that the screen must stay on the whole time. There's a non-free version too, which costs a few dollars and has more features.

The battery on my phone (an HTC Velocity 4G) lasts about three hours with Torque Lite running so for anything but a very long commute, you just need to recharge the phone overnight. That means no cables – great! For longer trips though, it will be necessary to run a charging cable from the car's accessory power or cigarette lighter socket to keep the power on for the duration of the drive.

There are a few other little issues with using a smart-phone as a speedo. For a start, if you happen to get a phone call while driving, you lose the Torque Lite display on the screen (at least temporarily) and you have to revert back to using your car's regular speedometer – even if you are using a hands-free system (and yes, hands-free Bluetooth still works while you are accessing the OBDII dongle).

Also, if you have a screen lock enabled, this may activate after the phone call and you'll have to wait until stopped to unlock the screen (we found this happened inconsistently, perhaps depending on the length of the call). That could perhaps be avoided by using a dedicated iPhone or Android device but that's a much more expensive proposition.

Also, we once had the phone spon-

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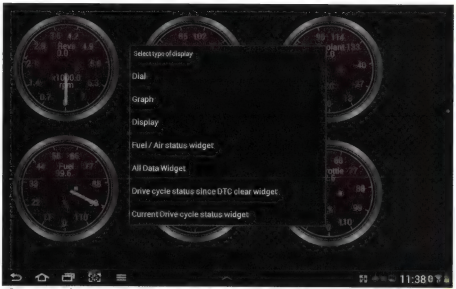
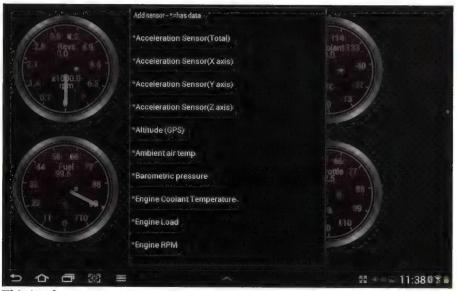


This screen lets you choose the display format for each readout, eg, dial, graph or digital display. You can customise and add displays to multiple pages.



This is where you use Torque Lite to select what you want to display. There's an impressive list of data to choose from (much more than shown here).

taneously reboot while we were using it which was a bit annoying. Plus you may need to clean the screen before clipping the phone into the dash-mount holder as greasy fingerprints on the touch-screen (perhaps more accurately termed "smudge-screen") can interfere with readability.

By the way, the Bluetooth adaptor runs off power drawn directly from the OBDII socket and while we haven't measured just how much current it draws, it should be somewhere in the range of about 5-50mA while operating. We left it plugged into the car over a long weekend and the battery still had plenty of charge to start so you can pretty much leave it plugged in all the time except if you will be leaving the car to sit for a week or more (or unless your battery is on the way out).

Removing or re-installing it is a pretty quick and easy exercise but if you do that too often, you may wear out the connector. SC

Excerpt from ADR

5.2.6. the test instrumentation used for measuring the true vehicle speed shall be accurate to ± 0.5 per cent;

5.2.6.1. the surface of a test track when used shall be flat and dry, and provide sufficient adhesion;

5.2.6.2. if a roller dynamometer is used for the test, the diameter of the roller should be at least 0.4 m;

5.3. The speed indicated shall not be less than the true speed of the vehicle. At the test speeds specified in paragraph 5.2.5. above [40km/h, 80km/h and 120km/h], there shall be the following relationship between the speed displayed (V1) and the true speed (V2).

$$0 \leq (V1 - V2) \leq 0.1\,V2 + 4\ km/h$$

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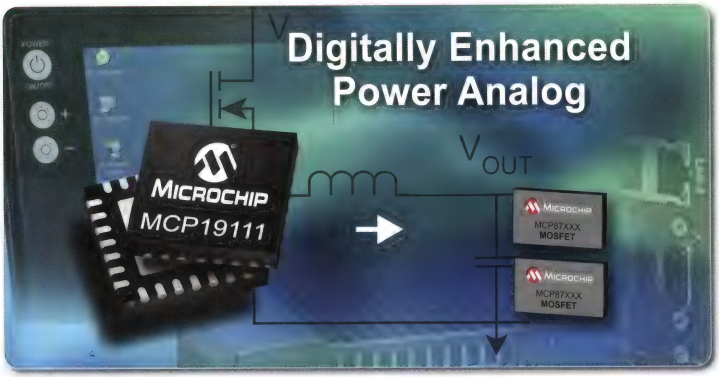

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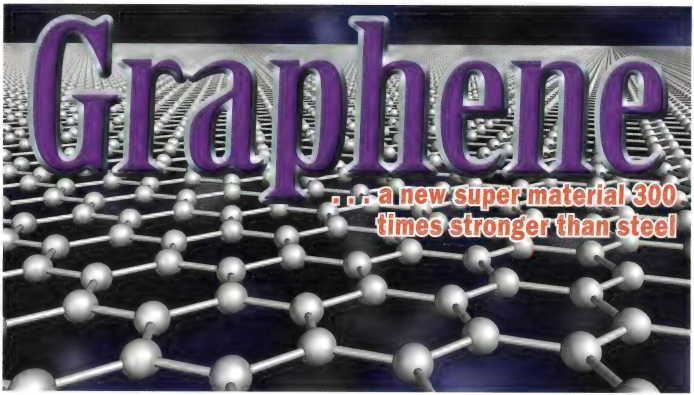


Above: a computer-generated atomic image of graphene showing the extensive 2-dimensional honeycomb-like structure. The shape of the structure is often compared with chicken wire. Image courtesy Sébastien Sauvage, CNRS.

Graphene has been billed as a new super-strong, super-thin exotic material with a vast range of exciting applications in electronics, materials science and so on. But what is it? We asked Dr David Maddison to investigate and report.

GRAPHENE IS the thinnest possible material. It is actually a single 2-dimensional atomic layer of pure carbon – only one atom thick!

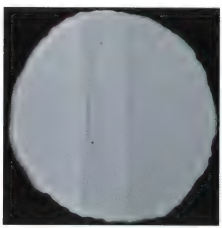


Image of graphene through an aperture showing a single layer (central stripe) and two layers (right side) with no graphene on the left for comparison. Each layer absorbs 2.3% of incident light. Image courtesy University of Manchester.

It has ultra-high tensile strength (300 times stronger than A36 structural steel at 130 gigapascals versus 400 megapascals), extremely low electrical resistance (almost like superconductivity under certain circumstances but at room temperature), very high stiffness whilst being able to be stretched by one fifth of its length before breaking, better thermal conductivity than copper and it is so impermeable that not even helium atoms can pass through it.

Graphene is as an "allotrope" of carbon, like diamond and graphite, because it is made of the same pure carbon element but it has a different atomic structure. In recent years, many other allotropes of carbon have also been discovered and these include buckminsterfullerene ("bucky balls"), amorphous and glassy carbon, lonsdaleite (hexagonal diamond, different from common diamond) and carbon nanotubes. It is quite likely that others will also be discovered in the future. Most of these new allotropes have unique and very useful properties.

Graphene can be thought of as a single atomic layer of the more familiar 3-dimensional graphite. In fact, this is an excellent example of an ordinary common material, carbon, being turned into an exotic and valuable material (much like silicon from silica or beach sand).

Incredibly light

Since graphene is a sheet only one atomic layer thick it is incredibly light. A single square metre of material weighs only 0.77 milligrams while an area the size of a tennis court would weigh just over 200 milligrams or one fifth of a gram. By contrast, if you used the same paper as used for printing this magazine (about 60 gsm), a tennis court-sized sheet would weigh about 16 kilograms.

Despite its thinness, graphene can actually be seen with the naked eye because it is not completely transpar-

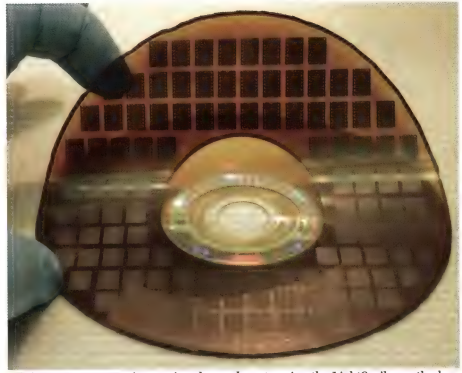
ent; it absorbs around 2.3% of the light that falls on it. This makes it visible enough to see.

Not only can graphene be seen with the naked eye, it is so strong that it can be picked up as a sheet. Indeed its strength is so high it is thought to represent the theoretical upper limit of how strong materials can possibly be. A sheet of multiple layers of graphene just 0.1mm thick (about the thickness of plastic cling wrap) would theoretically require a force of 2000kg to puncture it with a sharp implement.

Much work is now under way to make large sheets of the material so that it can be used in practical applications where such high strength is required. For large-scale applications such as this, it is likely that the graphene would be fabricated as a composite material much like carbon-fibre composites.

In addition to being extremely strong, graphene is also extremely stiff. A flake of graphene just 10 microns long (one hundredth of a millimetre, which is considered long for such a thin material) and one atomic layer thick will support itself without bending over when placed on edge vertically. This is equivalent to a 100-metre long sheet of paper supporting itself if it were placed on edge.

Being only one atomic layer thin, you might reasonably expect graphene to be totally invisible but what opacity it does have is related to the fact that the electrons in graphene behave as if they have no mass, unlike electrons in normal materials. In fact, the opacity of graphene allows the direct measure of one of the most fundamental physical constants of the universe, known as the "fine structure constant", which would normally require a very complicated apparatus to measure (the speed of light is another example of a fundamental constant).



Miniature supercapacitors printed on substrate using the LightScribe method. Photo courtesy University of California, Los Angeles (UCLA).

The 2.3% absorption of light by graphene equates very simply to the number π times α, where α is the fine structure constant. That it can be measured so simply using graphene is considered quite remarkable by researchers in the field.

The European Union consider graphene to be so important that they have established a Future Emerging Technologies flagship with research funding of one billion Euro over 10 years to commercialise graphene technologies – see http://www.graphene-flagship.eu/GF/index.php

Graphene is an extremely good electrical conductor as electrons can travel virtually without impediment within its structure. It is also an extremely good thermal conductor; better than copper. Indeed, one of its proposed applications is for cooling of semiconductor devices.

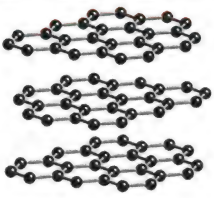
Bizarre properties

Some graphene properties even verge on the bizarre. It is impermeable to nearly all materials, including helium which is capable of even diffusing through glass (the ease at which helium diffuses through materials is why helium party balloons deflate so rapidly). However, one material known to be capable of passing through graphene is water.

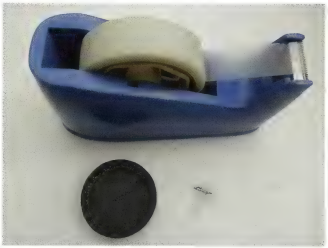
This is analogous to a chain link fence not allowing a tennis ball to pass through but allowing a basketball to do so. This property has even been proposed for use in a method to purify alcoholic spirits at room temperature without having to heat them as in a normal distillation process (graphene oxide is the material used in that application) and in water purification applications.

How to make graphene

In principle, it is easy to make small amounts of graphene. At the time graphene was characterised in 2004, it was made by bringing a piece of adhesive tape in contact with a piece of graphite and then examining what had been removed with an optical



Left: the atomic structure of graphite. Each ball represents a carbon atom and the lines represent the bonds between each atom. Note the layered, 3-dimensional structure which in reality extends indefinitely in accordance with the size of the graphite crystal. There is no strong bonding between the layers, only weak bonds and this accounts for graphite's "slipperiness" and its use as a lubricant among other applications. Graphene is made of a single such layer. Image courtesy David Darling.



A piece of graphite and a sticky tape dispenser was all it took to make graphene in 2004. Note the piece of tape with the graphite residue. Some of this residue will be in the form of graphene. Image source: Dr David Maddison.

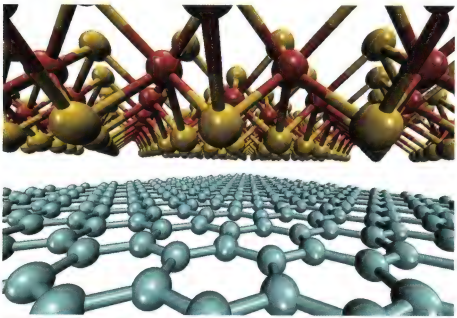
microscope or with powerful electron and scanning tunnelling microscopes. A video of this process can be seen at http://physicsworld.com/cws/article/multimedia/47356

The adhesive tape method has now been superseded by another simple fabrication method. In 2012, a group at University of California, Los Angeles (UCLA) made graphene using the LightScribe feature of a consumer-grade DVD drive. A water-based solution of graphite oxide is coated onto a plastic substrate and inserted into the DVD drive and then struck with a laser from the drive.

The oxygen atoms are removed from the graphite oxide coating by the heat of the laser and graphene is the result. Incidentally, this method is also used to make graphene by some very enthusiastic amateur scientists who have posted some *YouTube* videos on the process and even made some devices.

It is also possible that you have even inadvertently made graphene yourself. Although a fairly new material in terms of its discovery, naming and characterisation, graphene commonly results as a byproduct of everyday processes. For example, every time you write with a graphite pencil it is likely you will make some tiny pieces of it. It can also be created during combustion processes, along with other forms of carbon.

There are many other methods of prroducing graphene. One method is by chemical vapour deposition (CVD) onto various materials such as silicon carbide or metals such as copper to make so-called epitaxial layers. It is a similar process to that used to make various semiconductor devices from silicon. Such graphene layers may either be left in place or transferred elsewhere. This method is regarded by some as the likely route to mass production. Other methods can produce powdery material in a chamber which is then collected.



This diagram shows the atomic structure of a solar cell made with one layer of molybdenum disulphide on top and one layer of graphene below. Source: MIT News Service.

Historical precedents

Like many "new" concepts and processes, there are often historically relevant events that lead to a major discovery and graphene is no exception. As early as 1840, C. Schafheutl exfoliated graphite and may have made graphene.

In 1859, Sir Benjamin Collins Brodie was aware that graphite oxide that had had its oxygen removed to make pure graphite yielded extremely thin crystals, noting: "These crystals, when examined with the microscope, are perfectly transparent, and exhibit beautiful colours by the agency of polarized light". You can read his original scientific paper at http://www.jstor.org/stable/view/108699

There were also other studies on graphite oxide after that and in 1947 Professor Philip Wallace undertook extensive theoretical studies of the 2-dimensional form of graphite (which was not yet called graphene) in order to better understand the properties of 3-dimensional graphite.

There were also many studies on carbon thin films, including graphite of just a few layers thick, and electron microscope images of such material were produced as early as 1948. Hanns-Peter Boehm and co-workers were the first to specifically identify single-layer thick graphene sheets in 1961 and they published the results in 1962. However, they never thought of this as a discovery but merely an extension of much earlier work.

The characterisation of graphene resulted in the award of the 2010 Nobel prize in physics to Andre Geim and Konstantin Novoselov of the University of Manchester. The citation was "for ground-breaking experiments regarding the 2-dimensional material graphene".

Applications and devices

Because of its array of unique properties, many different applications

have been proposed for graphene. A number of prototype devices have been made, some of which are now discussed.

The LightScribe fabrication method has been used by UCLA to fabricate supercapacitors. Supercapacitors are different from normal capacitors in that they have much higher capacitance per unit volume and have much higher energy density. Because of this, they are being considered as battery replacements in personal electronic devices and electric vehicles (and for cars with the start/stop feature). They are better than normal electrochemical batteries because they can be charged and discharged much more rapidly.

Graphene supercapacitors

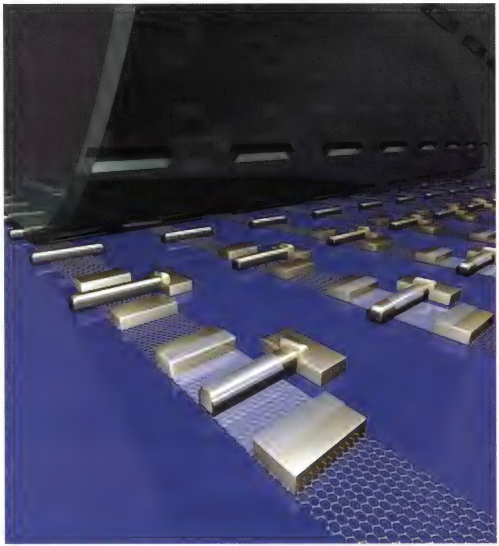
For supercapacitors, graphene is important for (a) enabling the creation of electrodes with a much greater surface area and thus electron storage capacity and (b) enabling an increase of the specific energy density of the supercapacitor. In one example, a graphene-based supercapacitor had a specific energy density of around 86Wh/kg at room temperature and 136Wh/kg at 80°C.

This compares favourably with lithium ion batteries with a typical energy density of 100-125Wh/kg but with the added advantage that they can be charged in seconds or minutes while batteries take many hours. In addition, supercapacitors can deliver energy much faster than batteries.

UCLA have developed a method using conventional lithography, deposition and etching processes along with a sacrificial substrate to mass-produce high-frequency graphene transistors. Switching frequencies up to 427GHz were achieved. And at the University of Manchester, individual graphene transistors have been developed with switching frequencies of up to 1.5THz (1500GHz).

The applications of such devices include computation, communications, high-speed chemical sensors and, if such a transistor could be made to work at 3THz (sub-millimetre waves), detection and production of the low-frequency side of the far-infrared radiation band.

An antenna made of graphene strips 10-100nm wide and one micron long that would transmit in the terahertz frequency range has been proposed by a team at the Georgia Institute of Technology. Such an antenna could transfer data at one terabit per second at distance of one metre and up to 100 Terabits per second at range of one centimetre.



An illustration depicting the mass-production of graphene transistors. Image courtesy University of California, Los Angeles (UCLA).

Nanyang Technological University in Singapore has developed a graphene -based image sensor for cameras which is 1000 times more light sensitive than current state-of-the-art sensors and sensitive over a broad spectrum of light. It also uses 10 times less energy than present sensors.

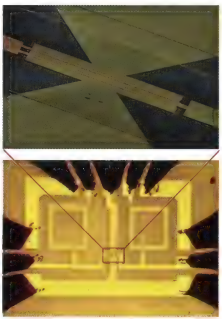
Graphene tennis racket

The first commercial application of graphene as an engineering material is by HEAD who have developed a tennis racket made from graphene-reinforced epoxy. Few details of its exact construction are known, however. Bulk graphene suitable for engineering applications is still extremely expensive although some grades can be obtained for around US$200 per kilogram.

Samsung have recently been awarded a patent for flexible touch screens utilising graphene for various elements. Graphene can potentially replace indium tin oxide, which is expensive and inflexible, as a transparent electrode material. It has also been used as an electrode material in flexible organic light emitting diode (OLED) displays.

Researchers at Rice University have recently reported the fabrication of electrodes for lithium batteries made from a mixture of tin oxide and graphene nano-ribbons. The nano-ribbons are made by splitting carbon nanotubes and opening them. This new electrode material may solve a significant problem of lithium batteries which is that the lithium causes electrodes to degrade over time.

A flexible touch screen developed at the University of Manchester in the UK. Image courtesy University of Manchester.



A photo of IBM's graphene integrated circuit. The enlargement at top shows the graphene transistor component. Image courtesy IBM.

Apple recently received a patent for graphene as a heat dissipation material. Graphite or graphite paste is used as a heat dissipation material in some mobile electronic devices. Apple proposes to replace the graphite with graphene which could be made much thinner than graphite because it is a much better thermal conductor.

Apple says that replacing a 30 micron (0.03mm) thick layer of graphite with graphene will free space inside the portable device for more electronics or battery capacity.

Graphene has been proposed as an electrode material on solar cells. Existing solar cells typically use indium-tin-oxide (ITO) as a transparent conductor but this material is expensive and brittle. Graphene has a high level of transparency and is also flexible. It could be used as an electrode on either conventional silicon solar cells or flexible organic or thin-film solar cells.

In fact, such an application was recently demonstrated at the Massachusetts Institute of Technology (MIT) and the performance was found to be equivalent to ITO. A further development at MIT is the production of solar cells just two atomic layers thick. One layer is composed of graphene and the other layer is molybdenum disulphide.

The cell is about 1-2% efficient; poor compared to conventional cells with efficiencies of 15-20% but greater efficiencies might be possible by stacking multiple layers together. While this concept has been successfully demonstrated, manufacturing such devices is a major challenge.

Integrated circuit

In 2011, IBM researchers fabricated the world's first integrated circuit using graphene as a component. The circuit worked as a broadband frequency mixer and could operate up to frequencies of 10GHz and at temperatures to 125°C.

Graphene can also be used to make conductive inks and coatings as well as act as a filler in plastics to make them more conductive.

A space elevator is a proposed space transportation system consisting of an extremely strong cable or ribbon (known as a "tether") which is attached to Earth in the region of the equator at one end and with a counterweight at the other end beyond geostationary orbit (35,800km altitude). A climbing vehicle would crawl along the ribbon to transport materials into space. Nano-engineered carbon-based materials such as graphene and carbon nanotubes are among the few ultra-strong materials that may be suitable for such an application.

Hyperbole

Like all new materials and technologies, graphene has been subject to its fair share of hype. The different stages of expectations and reality for new technologies is best illustrated by the Gartner Hype-Cycle (see Wikipedia). Many announcements related to graphene have been based more on hype than reality.

A HEAD Graphene Speed Pro 18/20 Racket made by HTM Sport GmbH, Austria.

There is no doubt, however, that graphene is an important new material. It is the first bulk 2-dimensional material. It has many possibilities but there are also many challenges to overcome before its use becomes widespread in electronics and other areas.

Having said that, as mentioned above, there is now one commercial product on the market, the HEAD tennis racquet. Undoubtedly, many more will follow. SC

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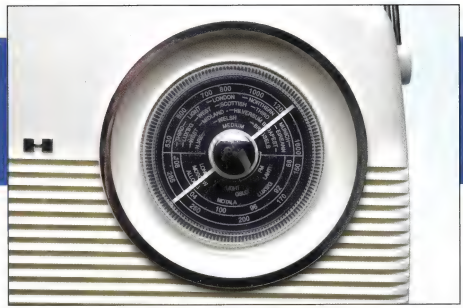
Review: Bush TR82DAB DAB+/FM/AM/LW radio

By LEO SIMPSON

Elsewhere in this issue we have a Vintage Radio article on the restoration of a Bush TR82C transistor portable radio which was introduced in the early 1960s. It became a highly-regarded classic and several reproductions have been made over the decades. Now there is the Bush TR82DAB which looks virtually identical to the 1959 original by Ogle Design but now incorporates modern circuitry with FM and DAB+ reception.

. . . classic 1960s styling, modern DAB+ circuitry



The dial-scale on the TR82DAB is a replica of the original TR82C design, with European station markings. A modern digital readout (LCD) on the top of the set shows the band selected, the tuned frequency and the signal strength, plus other useful information.

I PURCHASED this radio for my wife for use in the kitchen. Since then, it has been universally admired by all our visitors as a 'retro' radio which looks really 'cool'.

Little do they know that this radio has long been regarded as a classic. It looks as though some of the original moulds may have been used for the exterior of the case, at least, but the internals are quite different, as can be seen by comparing the photos in this article with those in the Vintage Radio column in this issue.

The original Bush TR82C only featured AM reception on the broadcast (MW or medium wave) and LW (long wave) bands. This TR82DAB model is the only DAB+ radio available in Australia which features AM as well as FM stereo reception (NB: the Marantz NA7004 Network Audio Player, as reviewed in the January 2013 issue, also has AM/FM/DAB+ but it is a far more expensive hifi program source.

The TR82DAB is also one of the few DAB+ radios which can be powered directly from the mains supply (ie, no plugpack) as well as an internal battery pack consisting of six C cells to provide 9V DC. The virtue of having AM & FM reception is that you can take the Bush radio on a trip or a picnic where DAB+ reception is not available and still be able to get most of the radio programs that you prefer to listen to.

Having said that, most people who do not possess a DAB+ radio do not realise that many more stations are available than the sum of all the AM and FM stations broadcasting in a particular city. For example, DAB+ includes the digital radio stations from the ABC and SBS networks which can be received on most digital TVs and set-top boxes.

This radio is much larger than many DAB+ radios on the market, with overall dimensions of 335mm wide, 270mm high (including the handle) and about 90mm deep. With batteries installed it weighs about 2.3kg, so it is not a lightweight.

For tuning the FM, AM and LW bands, there is a hand-span dial which is reasonably straightforward to use because it does have reduction gearing. All the other controls are in a recessed panel at the top of the cabinet, underneath the handle which looks as though it is supposed to retract onto the case, but it doesn't.

There are two thumbwheel knobs for volume and tone and the volume knob also doubles as the on/off control. Four pushbuttons select MW (AM), LW, FM or DAB+ operation. The DAB+ station information is displayed in a small LCD panel which is backlit in blue for about 20 seconds after one of the associated 12 buttons has been pushed. After that, the back light goes out but you can still read the information provided you are in a well-lit room.

The 12 buttons are labelled auto, menu, display, shift, select, > and <, while the rest are station presets. Ten DAB+ stations can be stored, to be retrieved at the push of the relevant preset button or two. When a DAB station is being received, you can push the display button to show the station information such as frequency, bit rate and signal error. All these functions work quite well and are reasonably intuitive.

On the rear panel is a socket for the 2-pin mains cord which must be unplugged from the radio if you want to operate from the internal batteries. Other than that, there is a centrally mounted screw which can be removed so that the whole rear panel can be slid down to reveal the battery compartment.

Batteries

You might note that I have fitted the set with standard carbon-zinc C cells, although alkaline cells would no doubt give far superior life. Battery life is important because I found that after not many hours of use, the radio would operate satisfactorily on FM or AM but refused to work on DAB+. So clearly it needs a fresh battery pack to work well.

It would have been preferable to be able to fit rechargeable cells to the radio but unfortunately, they would have to be removed for recharging. Since the radio has an internal mains transformer and DC supply, it would seem that the designers could have easily provided for the option of automatically recharging the cells. So why not?

Once the radio is out of warranty, it would be tempting to make up a rechargeable battery pack with sub-C NiMH cells and with trickle charging from the internal supply when mains power is available.

The radio's on/off switch only operates in the low-voltage DC supply rail so the mains transformer is permanently powered while ever it is plugged in and switched on at the wall. Standby

The rear of the case (left) carries a 2-pin mains socket and a telescopic whip antenna for listening to DAB+ and FM broadcasts. Undoing the large central screw allows the rear cover to be removed to access the battery compartment.

power consumption is less than one watt; about 880 milliwatts. When operating normally, power consumption from the 230VAC supply is typically around 4W or 5W, ranging up to over 7W when you have it really blaring.

Running from batteries (giving 9V DC), the current drain when in AM or FM mode is typically around 50-60 milliamps but when switched over to DAB+, the current rises to between 240mA and over 400mA when the volume is turned up. With that level of power consumption, it is fairly evident that the battery life will be relatively short.

Inside workings

Having removed the rear panel, you will find that nothing is revealed of the radio's internal workings. To reveal that, you need to remove umpteen deeply recessed screws and the front-mounted dial. Naturally, I could not resist the temptation to do so (after all, I wanted a photo or two) but it is not easy to reassemble it. Be warned; unless you need to gain access, leave it well alone.

Anyway, inside the set is a large PCB with lots of surface-mount devices. I could see the ferrite rod, the dial cord arrangement and some of the other details but I chickened out at the suggestion that I remove the PCB assembly to get more photos. After all, I needed to return the radio to my wife in good operating condition and with no signs that any meddling had occurred!

The radio has a whip antenna which needs to be vertical and extended to its full length of 580mm for best reception on DAB+ which has vertically polarised transmissions at just over 200MHz. But this length is nowhere near optimum for best reception on FM transmissions which range from 88-108MHz. This means that FM reception may not be quite as noise-free as it might be if it had a longer whip antenna. In metropolitan areas, that probably won't matter.

For AM (MW & LW) reception, the Bush radio has a ferrite-rod antenna which appears to give good reception of both local and more distant stations.

Sound quality

What about the sound quality? I have already commented in the past that DAB+ sound is not as good as it could because the data rates used by most stations are 64kb/s or less, with only a couple of stations using 80kb/s. Well, the problem is that the Bush only has one loudspeaker which is about 95mm in diameter.

Yes, it is only mono so that as far as listening to it as a normal radio, you can have all stations in one-dimensional monophonic sound and while it is reasonably pleasant it is no rival to a Bose radio. As you might expect, there is minimal bass and not a great deal of treble; it is pleasant but not hifi.

I should state, though, that it still sounds better than most other DAB+ radios which typically have smaller speakers again and they are also usually mono to boot.

Fortunately, the TR82DAB does have two 3.5mm stereo jack sockets at the right-hand side of the cabinet and these enable you to listen to earphones or headphones or you can feed its stereo line-level signals to an external stereo amplifier and loudspeakers. In this mode, first impressions are that the sound quality is quite good. DAB+ reception is generally cleaner and more noise-free than any equivalent stations on the FM or AM bands.

However, on closer listening, switching between FM and DAB+, I have to say that DAB+ sounds more "restricted" and somehow lacking the finer detail of FM, especially when comparing the fine music stations. That is after allowing for the fact that the background hiss on FM can add to the impression of more treble. Apparent bass output is better than the internal speaker but there doesn't appear to be much output below 100Hz or so.

Finally, I should state that the DAB+

is consistently much cleaner and better overall than AM reception, provided you have reasonable signal strength; if not, it will periodically drop out or just mute itself.

Performance measurements

We do not have facilities for measurement of DAB+ performance so we were restricted to limited measurements on the AM and FM bands. Nor does the radio have any external antenna connections so any measurements we we did were those with signals fed into the extendable whip antenna.

Going to AM mode first, it was difficult to get any sort of signal into the radio but we did manage to measure the overall audio bandwidth. No surprises there; it is actually a bit worse than the normal mediocre bog-standard AM response: ie, 100Hz to 2.5kHz at the -6dB points. There was little point in trying to measure harmonic distortion, signal-to-noise ratio or anything else since the degree of coupling into the ferrite rod antenna from our signal generator was obviously very poor.

On FM, we were able to do better. While we were not able to do sensitivity measurements, we were able to measure mono signal to noise ratio at 63dB while stereo signal-to-noise ratio was just a few decibels worse which is quite commendable really.

Total harmonic distortion (mono) was typically around 0.5%, though rising markedly in the bass region below 100Hz. Frequency response is certainly much better than AM, as you would hope, but still well short of a good FM stereo tuner in the days of yore. With respect to 1kHz, the response is about +3dB at 5kHz, 0dB at 8kHz and -3dB at 10kHz. Below 1kHz, the response tapers to -6dB at 100Hz and then rolls off at 12dB octave below that.

Considering that the Bush radio is using up-to-the-minute circuitry for its DAB+ reception, it is a little disappointing that the rest of its performance is fairly mediocre by comparison; it could so easily have been much better for possibly only a dollar or two in manufacturing cost. Still, so much consumer equipment these days is even more mediocre.

The digital readout & all the controls except for the AM/LW/FM tuning wheel are in a recessed panel at the top of the cabinet.

This is the view inside the unit with the front cover removed. Most of the parts are mounted on a single large PCB.

Conclusion

Overall, I have to say that the Bush TRD82DAB radio is an attractive unit and its performance is perfectly suited to the vast majority of consumers. They will "love it". Further information can be obtained from the local distributor, Bush Australia at www.bushaustralia.com.au It is well worth shopping around for the best price. SC

Speedo Corrector, Mk.3

By JOHN CLARKE

Correct your car's speedo after swapping the wheels, gearbox or differential

If you have swapped your car's instrument panel, gearbox or differential with one from a different vehicle, your speedometer and odometer may no longer be correct. The same thing applies if you have fitted wheels or tyres with a different diameter. The solution is to use our updated Speedo Corrector which can increase or decrease the indicated speedometer reading. It operates from 12V or 24V DC and is simple to set up.

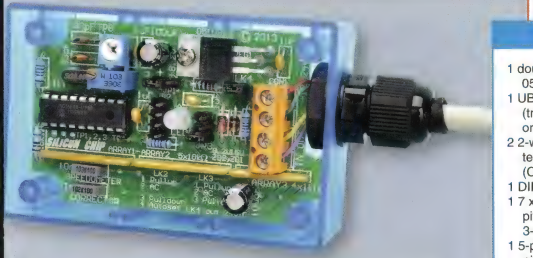
IF YOU HAVE made any of the aforementioned modifications to your vehicle, you will almost certainly need to correct the speedometer and odometer readings.

The Speedo Corrector can adjust your vehicle's speedometer to show the correct road speed. It will work with analog or digital speedometers that use a frequency signal for speed sensing. It will not work with older speedometers that use a mechanical cable unless you make a new speed pick-up with Hall Effect sensor and magnets on a driveshaft. Nor will it work with some the latest vehicles that have speedometers that connect to the Controller Area Network (CAN) bus instead of using a dedicated speedometer signal. CAN bus is a communications system between sensors and instruments in the vehicle.

The Speedo Corrector intercepts the signal from the speed sensor and then increases or reduces its frequency before it is applied to the speedometer. Note that the Speedo Corrector will not correct for non-linearities in the speedometer but fortunately most speedometers are proportional in the region of 40-100km/h and so correc-

Main Features

- Allows alteration of speedo reading so that it reads faster or slower over a wide range
- Caters for three input signal types
- Automatic or manual set-up of input signal type
- LED indication of valid speed sensor signal being received during set up
- 12V or 24V operation (set using a link)
- Adjustable response rate to compensate for speedo lag
- LED and output voltage rate adjustment indication



The compact PCB assembly clips into a UB5 plastic utility box. An on-board trimpot allows its output pulse frequency to be adjusted so that the car's speedo matches the speed read-out on a GPS.

tion at one speed in this region should provide the correct speed reading at other speeds.

You will need to be able to access the speedometer signal in your vehicle to be able to install the Speedometer Corrector. This may require disassembly of the dashboard or steering column (see below).

Optimistic readings

With most unmodified vehicles running with standard sized tyres, the speedometer will tend to read optimistically, showing a higher than actual speed. So a speedometer indication of 100km/h could mean you are actually travelling between 87.27km/h and 100km/h, depending on the particular speedometer's accuracy. That's because the Australian Design Rules (ADR) (ADR18/00 and ADR18/03) specify speedometers to have an accuracy that is within +10% +4km/h for speeds above 40km/h. Alternatively, at an actual speed of 100km/h, your speedometer could read anywhere between 100km/h and 114km/h and still be within ADR specs.

Vehicles manufactured before 1995 are worse and could have speedometers that are within ±10% of the actual speed. Should the speedometer be within the pessimistic 0-10% range, then the speedometer will show a slower speed than you are actually travelling. That means that you could inadvertently exceed the legal speed limit and risk a hefty fine or loss of licence. In that case, the speedometer certainly needs to be corrected so that it shows the true speed!

Note that the odometer in a vehicle is required to have an accuracy within ±4%. For a modified vehicle, the odometer will require correction to bring it to within the ADR spec.

Elsewhere in this issue, we have an article on head-up display (HUD) speedos based on GPS or the vehicle's OBDII (on-board diagnostics) socket. However, while these devices will give you a more accurate speed reading than the vehicle's speedometer, they will not correct the odometer which our Speedo Corrector can do, to bring it within the required accuracy range. That way, upon resale of the vehicle, the correct vehicle mileage will be shown.

Both the speedometer and odometer use the same speed signal that's taken either from a sensor in the gearbox or a wheel sensor that is also used for the anti-lock braking system (ABS). The common signal for both speedo and odometer means that altering the sensor signal will change both the odometer and speedometer readings.

Australian Design Rules mean that the speedometer is typically less accurate than the odometer but the Speedo Corrector Mk.3 (ideally) should be calibrated for both to be within the ADR specification. A GPS speedometer can be used as a guide to the correct speed adjustment while roadside odometer check signs can verify the odometer accuracy.

The Speedo Corrector Mk.3 is a major revision of the Speedo Corrector published in the December 2006 issue of Silicon Chip. This new version is considerably smaller, making it easier to install in a vehicle. It now operates from 12V or 24V and includes the original features such as automatic or

Parts List

1 double-sided PCB, code 05109131, 78 x 46mm
1 UB5 box, 83 x 54 x 31mm (translucent blue, clear, black or grey)
2 2-way PCB-mount screw terminal blocks, 5.08mm pitch (CON1)
1 DIL18 IC socket
1 7 x 2 DIL pin header (2.54mm pitch) broken into 4-way & 3-way headers (JP2,JP3)
1 5-pin SIL header (2.54mm pitch) broken into 3-way & 2-way headers (JP1,LK4)
1 10kΩ 20-turn top-adjust trimpot (VR1)
1 10kΩ miniature horizontal mount trimpot (VR2)
5 jumper shunts
1 20MHz crystal (X1)
1 M3 x 10mm screw
1 M3 nut & shakeproof washer

Semiconductors

1 PIC16F88-E/P microcontroller programmed with 0510913A.hex (IC1)
1 LM2940CT-5 TO-220 5V low dropout regulator (REG1)
4 BC846 (SOT23) NPN SMD transistors (Q1,Q2,Q3,Q5)
2 BC857 (SOT23) PNP SMD transistors (Q3,Q6)
1 15V 1W zener diode (ZD1)
1 8.2V 1W zener diode (ZD2)
1 bi-colour (red/green) 3mm or 5mm LED (LED1)
2 PC stakes (TPG & TP4)

Capacitors

2 100μF 16V PC electrolytic
3 1μF monolithic multi-layer ceramic (MMC)
1 10nF MKT
1 1nF MKT
2 33pF NP0 ceramic

Resistors (0.25W, 1%)

1 6.8kΩ 1 220Ω 0.5W
2 1kΩ 1 10Ω

Resistor arrays

2 5-way 10kΩ resistor arrays (4610X-102-103LF)
1 4-way 1kΩ resistor array (4608-102-102LF)

Specifications

Output ratio: adjustable from 1 to 1/6 the rate for lower output frequencies and from 1 to 6 times for higher frequencies.
Adjustment resolution: < 0.4% for 1x to 2x and 1x to ½x adjustments; < 0.8% for 2x to 4x and ½x to ¼x; < 1.8% to x6 and x1/6
Minimum input or output operating frequency: 1Hz.
Maximum input & output frequency to maintain maximum adjustment resolution: 1.2kHz.
Response rate adjustments: 1s (fully anticlockwise), 500ms, 250ms (mid setting), 125ms and 62.5ms (fully clockwise) – set using VR2.
Input and output types: pull-up, pull-down or AC.
Output swing: 0-8.2V or 0-5V or 8.2V peak-peak AC or 5V peak-peak AC.
Maximum input voltage: 50V RMS.
Minimum input sensitivity: 0.7V peak (on high sensitivity setting); 2.5V peak (on low sensitivity setting).
Power: 9-30V DC at 25mA.

manual set-up to suit the speed signal sensor and an AC signal output to suit Nissan speedometers. The overall adjustment range has also been increased over the original version.

And instead of using two expensive rotary switches (as in the 2006 version) to set the adjustment, we now use a low-cost multi-turn trimpot. A bi-coloured LED shows green for adjustments that increase the output frequency and red when the output frequency is reduced (with respect to the input signal). A test point is provided to allow a multimeter to monitor the amount of adjustment that's set.

Mechanical Speedo?

The Speedo Corrector Mk.3 will work only on electronic speedometers, ie, those that don't have a mechanical rotating cable driving them. If you have an older car with a mechanical speedo, then you won't be able to correct it – at least not using this circuit.

Non-Linearity?

The Speedo Corrector Mk.3 will not compensate for non-linear errors. In other words, if the speedo reads 10% high at 25km/h and 4% high at 100km/h, you won't be able to use the Speedo Corrector Mk.3 to get the speedo accurate at all speeds.

However, most speedo errors are proportional and so can be dialled-out with the Speedo Corrector Mk.3.

In practice though, it is usually not necessary to monitor the degree of adjustment. The relevant trimpot (VR1) is simply adjusted so that the speedometer or odometer reads correctly, compared with a GPS speedo or roadside odometer check markers (at 1km intervals).

The Speedo Corrector is housed in small plastic case measuring 82 x 53 x 30mm. It can be concealed anywhere underneath the dashboard.

Circuit description

Fig.1 shows the circuit which is based on IC1, a PIC16F88-E/P microcontroller. It's programmed to alter the incoming speed signal frequency by a factor set using trimpot VR1.

Transistors Q2, Q3 & Q4 are included to provide for speedometer sensors that require pull-up or pull-down resistors. Q3 & Q4 are turned on by RA4 (pin 3) to provide pull-up via a 1kΩ resistor or Q2 is turned on by RA3 (pin 2) to pull the same resistor down, or all the transistors are left turned off if no pull-up or pull-down is required (in the case of an AC sensor).

Whether or not Q2, Q3 & Q4 are turned on is controlled by IC1 in response to the links for JP2, connected to its RB2, RB4, RB5 & RB7 pins (8, 10, 11 & 13).

As well as providing options for pull-up, pull-down etc, there is an 'Autoset' mode whereby the Speedo Corrector software will select each setting one at a time until the micro gets a satisfactory signal. With each selection, the program waits to check if it receives at least 20 cycles of signal within a 1-second period. If not, it moves on to the next selection. When it does receive signal, that input selection is stored in memory and used thereafter.

Manual selection via the jumper links is provided for installers of the unit who already know the required input condition for particular vehicles. Manual selection can also be used should the automatic Autoset not work successfully on your vehicle.

All the resistors on the circuit marked with an asterisk (*) are in resistor arrays: two 10-pin arrays comprising five 10kΩ resistors in each and a single 8-pin array comprising four 1kΩ resistors. The arrays save space on the PCB.

After being pulled high, low or neither, the input signal is fed to the base of Q1 via a low-pass filter consisting of a 10kΩ resistor and 10nF capacitor and then via another 10kΩ resistor. A 6.8kΩ resistor at the base of Q1 can be either connected to 0V or left floating under the control of the RA2 output of IC1. When floating, Q1 will be switched on with a 0.7V input signal, corresponding to the high-sensitivity setting. When the 6.8kΩ resistor is connected to 0V, the signal level required to switch Q1 is increased to about 2.5V (the low sensitivity setting).

The signal at Q1's collector is filtered with a 1nF capacitor and fed to the RB0 input, pin 6, of IC1. This has an internal Schmitt trigger to ensure a clean signal. The microcontroller then increases or decreases the signal frequency according to the program and feeds it out from its RB1 output at pin 7 to the base of transistor Q5. Q5's collector load is a 1kΩ resistor connected to the +8.2V or +5V supply, as selected by link JP1. Q5 drives Q6 which has two paralleled 1kΩ resistors (in the 8-pin resistor array, mentioned above). This is done to provide a relatively low impedance pull-down output.

Links at JP3 provide the options for pull-down, pull-up or AC-coupling for the output signal. Note that the pull-up signal comes from the collector of Q5 while the pull-down or AC signal comes from the collector of Q6.

VR1 is used to set the degree of speedometer correction. The voltage at VR1's wiper is applied to the AN0 input of IC1 and is converted to a 9-bit digital value. With the wiper centred, the speed signal passes through unchanged. Winding the trimpot clock-

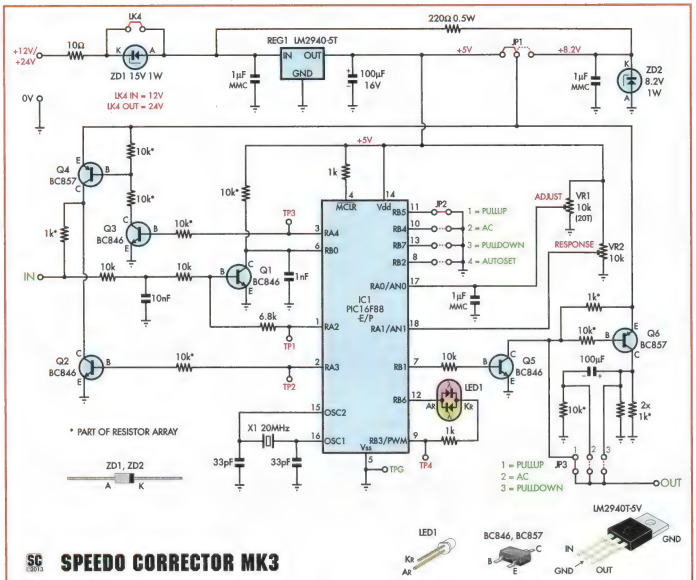


Fig.1: the circuit is based on PIC microcontroller IC1. It takes the speedo signal and multiplies it according to the setting of trimpot VR1. The speedo signal frequency can be either increased or decreased.

wise increases the signal frequency while winding it clockwise reduces the frequency.

The bi-coloured LED (LED1) connected between pins 9 & 12 indicates frequency increase or decrease, as previously mentioned. When VR1 is set at mid-setting, both the red and green sections are driven equally and the resulting orange colour indicates 'no change' in output frequency, corresponding to a 50% duty cycle of the 19kHz pulse width modulation (PWM) signal at pin 9. At the same time, the voltage at test point TP4 will be at 2.5V.

For other settings of VR1, the RB6 output at pin 12 will be either low or high; low for green and high for red. The LED brightness will vary slightly with the PWM duty cycle but this is not sufficient to gauge the degree of adjustment off centre for VR1.

Setting speedometer response

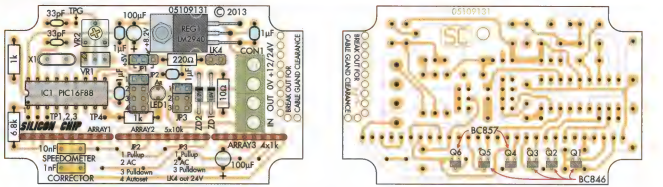
Different speedos respond at different rates to a change in the signal frequency. The Speedo Corrector Mk.3 can compensate for this by varying its response period which can be adjusted from between 1s and 62.5ms. The required setting used depends on the response of the speedometer when the vehicle comes to a stop. If the speedometer takes too long to drop back to zero with a 1-second response, then it should be reduced with trimpot VR2.

IC1 operates at 20MHz using crystal X1. This frequency was chosen so that the software program runs sufficiently fast to operate with speedometer signals up to 1.2kHz. Note that the Speedo Corrector Mk.3 will operate with signals above 1.2kHz but the accuracy of correction will be reduced.

An internal power-on reset for IC1 is provided using the MCLR-bar input at pin 4 and is connected to the 5V supply via a 1kΩ resistor. This keeps the IC reset until the power supply voltage is correct.

Power for the circuit is applied via a 10Ω resistor and a 15V zener diode (ZD1) to an LM2940-5T 5V automotive regulator, REG1. For 12V operation, ZD1 is shorted out with link LK4. For 24V operation, LK4 is removed and ZD1 effectively subtracts 15V from the supply applied to REG1.

An 8.2V supply is provided using ZD2 and the 220Ω resistor. This supply



TOP VIEW OF PCB

BOTTOM VIEW OF PCB

Fig.2: follow these two diagrams to build the unit, starting with the six SMD transistors (Q1-Q6) on the back of the PCB. Install link LK4 for 12V operation or remove it for 24V operation. The other linking options are explained in the text.

ALTERNATIVE TO RESISTOR ARRAY USING SINGLE RESISTORS

Fig.3: single resistors mounted end-on can be used instead of the resistor arrays. You would need 10 x 10kΩ and 4 x 1kΩ resistors.

can be selected to give a higher signal output from the corrector which is necessary for reliable operation with some speedometers.

Construction

The Speedo Corrector is built onto a double-sided PCB with plated through holes. This board is coded 05109131, measures 78 x 46mm and is designed to clip into a plastic UB5 box measuring 83 x 54 x 31mm.

A hole is made in one end of the box to allow a cable gland to be fitted to allow wire entry (input and output signals plus supply leads). Alternatively, the leads can be run out through a grommet and restrained inside the box using a cable tie.

If you intend fitting a cable gland, it will be necessary to snap off a breakaway section located at one end of the PCB, to allow space for the cable gland nut inside the box (see photo).

Fig.2 shows the parts layout on the PCB. First, check the PCB for any faults (rare), then start the assembly by installing the six SMD transistors on the underside of the PCB. Note that Q1, Q2 & Q5 are BC846s, while Q4 & Q6 are BC857s, so be careful not to get them mixed up.

You will need a good light (preferably a magnifying lamp) and a fine-tipped soldering iron for this job. The procedure is straightforward: carefully place transistor Q1 in position, hold it down with some tweezers and solder one of its leads first. That done, make sure that it's positioned correctly (remelt the solder and nudge it if necessary) before soldering the other two pins.

Repeat this procedure for the remaining five SMD transistors, taking care to fit the correct type to each location.

Once the SMD devices are all in place, flip the board over and install the single resistors and zener diodes. Table 1 shows the resistor colour codes but it's a good idea to check each one using a digital multimeter before soldering it into position.

Make sure that the zener diodes are installed with the correct polarity, ie, with the banded ends orientated as shown on Fig.2. Don't get these two devices mixed up – ZD1 is a 15V zener, while ZD2 is an 8.2V zener.

There are two PC stakes to be installed and these go in at test points TPG and TP4. PC stakes are not installed at TP1, TP2 & TP3, as these test points can be monitored by touching a multimeter probe on the plated PCB pads provided.

Resistor arrays

The resistor arrays are labelled 10X-2-103 (5 x 10kΩ) and 8X-2-102 (4 x 1kΩ). These can be installed now and can go in either way around.

Alternatively, you can use single resistors mounted end-on in place of the arrays, as shown in Fig.3. You would need to install 10 x 10kΩ resistors instead of the two 5-way arrays and 4 x 1kΩ resistors instead of the 4-way array.

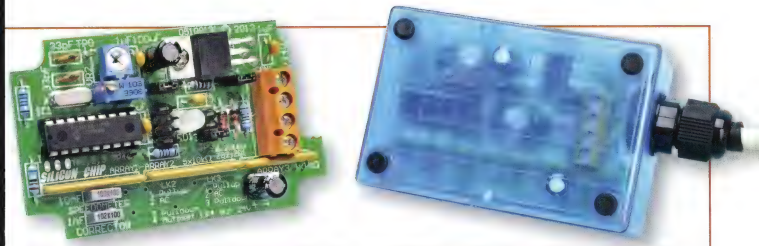
The 20MHz crystal (X1) and an 18-pin IC socket for IC1 can be fitted next. The socket must be orientated with its notched end towards the adjacent edge of the PCB. Follow with regulator REG1; it's mounted horizontally and secured with an M3 screw, shakeproof

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
10nF	0.01µF	10n	103
1nF	0.001µF	1n	102
33pF	NA	33p	33

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown



Take care to ensure that microcontroller IC1 and the other polarised parts are orientated correctly and don't get the SMD transistors mixed up. The signal and power leads exit the case through a cable gland, as shown at right.

washer and nut. Bend its leads at right angles before installing it and be sure to tighten it's mounting screw before soldering the leads.

Don't do this in reverse order. If you solder the leads first, you could crack the PCB tracks as the mounting screw is tightened down.

Now for the capacitors. The ceramic and MKT types can go in either way around but the 100µF electrolytic must be orientated as shown.

The 4-way and 3-way dual-in-line pin headers for JP2 and JP3 are next. Push them all the way down onto the PCB before soldering their leads.

Indicator LED

LED1 is mounted so that it sits directly on (or very close) to the PCB. Make sure it's orientated correctly with its anode (longer lead) going to the pad marked 'AR'.

That done, install trimpots VR1 & VR2 and the 4-way screw terminal block. VR1 is mounted with its adjusting screw towards the crystal. The 4-way screw terminal block is made by dovetailing two 2-way terminal blocks together. Push it all the way down onto the PCB and make sure its wire entry holes face outwards before soldering the pins.

Initial tests

Before plugging IC1 into its socket, connect a jumper across LK4 and apply 12V to the circuit (ie, between the 12/24V and the 0V input terminals). That done, check that the voltage between pins 5 & 14 of IC1's socket is around 5V (you should get a reading that's between 4.85V and 5.15V).

If this is correct, disconnect the power and plug microcontroller IC1 into its socket, taking care to orientate it correctly. Make sure that none of the IC's pins are bent under the socket or splayed down the side during this procedure.

With IC1 now in place, reapply power and adjust VR1 to its mid setting. This is indicated when both the green and red colours in LED1 flash. If the LED is red, rotate VR1 clockwise to reach mid setting. If the LED is green, rotate VR1 anticlockwise until mid setting is reached.

Installing the jumpers

Before installing the Speedo Corrector in your vehicle, you need to fit the relevant jumper links.

First, either leave the jumper on LK4 for 12V operation or remove it for 24V operation. That done, install jumper JP1 in the 5V position but don't fit a jumper to the JP3 header yet.

Most readers should also install a jumper in position 4 on header JP2 (ie, in the Autoset position) for automatic setting up. The response trimpot (VR2) should initially be set fully anticlockwise for a 1s response time.

In some cases, you may already know the required jumper settings for the vehicle (eg, if you've already installed a Speedo Corrector Mk.3 in a similar vehicle). In that case, fit a jumper in position 1 of JP2 for pull-up, position 2 for AC or position 3 for pull-down. Low-sensitivity AC requires jumpers in both positions 2 & 3 but ignore this for the time being.

The JP3 setting needs to duplicate the JP2 selection, ie, a jumper in position 1 for pull-up, position 2 for AC and position 3 for pull-down.

As stated though, if you don't know the settings, fit a jumper to position 4 (Autoset) of JP2 and leave the jumper off JP3.

Installation

Now for the installation but first a word of warning: in some cars, it will be necessary to partially dismantle the dash in order to locate the power supply wirer and speed input wire to the speedo. **If you need to disassemble any of the steering wheel section, take care if an air-bag installed as this will have to be disabled.**

Generally this means disconnecting the vehicle's battery and waiting for a set period before it is safe to disassemble the column. **However, check the manual for your car and make sure you know exactly what to do to disable the airbag before proceeding. If in doubt, don't!**

In practice, the Speedo Corrector must be connected to either a 12V or 24V ignition-switched supply, with the 0V line going to chassis. Be sure to use automotive cable for these connections and make sure you connect to a fused supply rail (eg, for the accessories).

The signal input wire to the speedo must be cut so that the Speedo Corrector Mk.3 can be inserted in-line with it. This wire will usually come either directly from a speed sensor or it may come from the ECU and you can generally find it in the dashboard space behind the speedometer. A wiring diagram for your vehicle will come in handy for tracking down this wire.

Depending on the vehicle, removing the dashboard panels can be a difficult undertaking and may not be

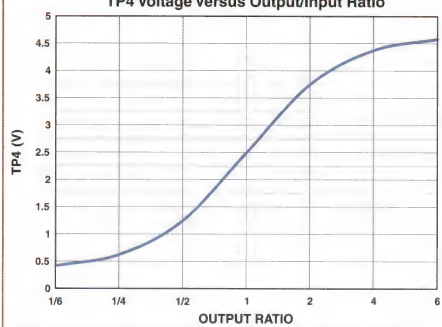


Fig.4: you can use this graph to determine the voltage that needs to be set at TP4 for a given frequency output ratio. It works in reverse too – if the Speedo Corrector has been adjusted using a GPS, you can determine the output ratio from the graph after first measuring the voltage on TP4.

something you want to do. In that case, tracking down the speed signal wire elsewhere in the vehicle is the way to go but, of course, you will need a wiring diagram. In other cases, it may be possible to find the dashboard disassembly instructions on the internet, especially for older cars.

Once you've located the speed signal wire, cut it and connect the Speedo Corrector Mk.3's signal input to the lead coming from the speed sensor or ECU. The corrector's output is then connected to the wire running to the speedometer.

Initially, you should make the leads to the Speedo Corrector Mk.3 long enough so that it can be dropped down from behind the dash and easily accessed by someone sitting in the front passenger seat. Once it's all wired up, you can jump straight to the calibration section below if you have already manually set up the jumper links.

Alternatively, for Autoset, you have to follow these simple steps:

(1) Start the engine and check that LED1 lights red.

(2) Drive the car for a minute or so with a passenger (note: the speedo will not be working at this stage).

(3) Wait until the LED flashes green at a 1-second rate. This shows that the Speedo Corrector Mk.3 has automatically set itself to cater for the type of speedometer signal that is present and is receiving a valid signal from it.

(4) Once a valid signal has been received, get the passenger to remove the Autoset jumper. Note that the power must still be on when removing the Autoset jumper in order for the settings to be stored. If this has been successful, the LED should now alternately be flashing red and green to indicate that the unit is operating normally (although the speedo will still not be working).

(5) If the LED doesn't flash, check the signal wiring from the speed sensor. If the wiring is correct, try the 8.2V setting for JP1 and drive the vehicle again.

(6) If it is still "no go", try manually setting the jumpers on JP2 and JP3 (they have to agree) and test each setting in turn. First, remove the Autoset jumper, then start with the Pullup jumper option (ie, position 1 for both JP2 & JP3) and drive the vehicle to see if the speedo works.

If it doesn't, change the settings until the speedo works. Position 2 (AC) for both JP2 & JP3 can be selected next, followed by position 3 (Pulldown). The final selection to try is low-sensitivity AC, ie, install jumpers in both positions 2 & 3 of JP2 and in position 2 of JP3.

(7) If you got the speedo working with the Autoset function, you now need to install a jumper at JP3. It's just a matter of trying each jumper setting in turn until the speedometer starts working.

Alternatively, you can determine the set-up by making some simple voltage measurements. TP2 will be at 5V if the selection is Pulldown, while TP3 will be at 5V if the selection is Pullup. For AC, both TP2 and TP3 will be at 0V.

Test point TP1

OK, so what's the purpose of test point TP1? It's there so that if an Autoset sets the input for AC, TP1 can be checked to see if the associated 6.8kΩ resistor is tied to 0V for low sensitivity or left floating for high sensitivity. This may be of interest to installers so that they can check what the settings are for each vehicle.

For example, if the voltage between TP1 and TPG reads 0V (with power applied), then input to the 6.8kΩ resistor is probably tied to 0V. However, if you place your finger on test point TP1 to inject noise and the voltage changes, then TP1 is floating. This means that the input to the 6.8kΩ resistor is also floating.

Calibration

You will need an accurate reference to correctly calibrate the speedo. This can be provided by a GPS unit or a GPS speedometer. Just make sure that you have an assistant make the necessary adjustment as you drive! It's simply a matter of adjusting VR1 in the Speedo Corrector Mk.3 until speedo gives the correct reading (ie, agrees with the GPS).

You can also use the odometer check distances that are marked on some roads to check the accuracy of the odometer.

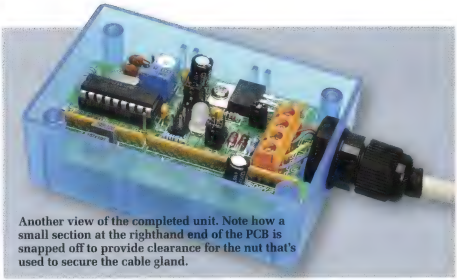
Alternative approach

You can also adjust the Speedo Corrector for a certain ratio based on known wheel, differential or gearbox

Tacho As Well?

The Speedo Corrector Mk.3 will also work with electronic tachos that take their feed from the ECU (ie, all cars with engine management).

The configuration procedure is the same as for use of the device as a speed interceptor, except that the "speed sensor" becomes the tacho output signal from the ECU. This application is particularly suited to engine and gearbox swaps.



Another view of the completed unit. Note how a small section at the righthand end of the PCB is snapped off to provide clearance for the nut that's used to secure the cable gland.

ratio changes. Basically, test point TP4 allows you to monitor the ratio between input and output frequency. This test point nominally sits at 2.5V when the input and output frequencies are equal but goes above 2.5V when the output frequency is higher than the input frequency.

Conversely, TP4 goes below 2.5V when the output frequency is lower. Note that TP4's voltage is non-linear with respect to frequency changes.

The accompanying graph (Fig.4) shows the relationship between the voltage at TP4 and the output:input frequency ratio. So to set the unit for a known output ratio, simply use the graph to read off the required voltage for TP4.

Trimpot VR1 is then adjusted to bring TP4 to this value.

If a high degree of accuracy is required, measure REG1's output (Vreg) and then multiply the voltage read off the graph by Vreg/5.

You can also use Fig.4 to look up the ratio that's been set using VR1 if you have calibrated the unit against a GPS. It's just a matter of measuring the voltage at TP4 and then looking up the ratio on the graph. For best accuracy, multiply the TP4 reading by 5/Vreg before checking the ratio.

Note that the voltage reading will not provide an extremely accurate value to calculate the adjustment setting. That's because the PWM output is loaded by the indicating LED.

Final trims

If you have manually set the input selection for AC, you can experiment by also placing a low-sensitivity jumper in position 3 of LK2. This may result in smoother operation of speedometer compared to when this jumper is left out. Select the setting that gives best results (ie, jumper in or out).

Additionally, when there is an Auto-set selection of AC (both TP2 and TP3 at 0V), the sensor signal may have required a pull-down setting in order to allow satisfactory operation at high speeds without dropping out. An inherent pull-down is provided by the 6.8kΩ resistor on the base of Q1 but this may not be sufficient to pull the signal down fast enough at high frequencies. If you experience speedometer drop-out at high speeds, try installing a jumper at position 3 for JP2 to give manual pull-down.

Another possible problem is that the speedo may some show some lag when the vehicle abruptly comes to a stop from a slow speed. When this happens, the speedo may show a reading for up to 1s after the vehicle stops.

Speedo lag could also be evident when moving off from a standstill. In this case, the speedo initially shows 0km/h before then suddenly jumping to the correct speed reading.

This problem can be overcome by adjusting response trimpot VR2. At its full anticlockwise position, the response lag is 1s. As the trimpot is adjusted clockwise, the response becomes faster at 0.5s and then 0.25s at mid-setting. Further rotation provides 0.125s and then 62.5ms at VR2's full clockwise position.

The optimal setting is when the adjustment provides the shortest lag while still reliably operating the speedo at slow speeds.

Once the Speedo Corrector is working properly, the lid can be attached and the unit tucked up behind the dash out of sight. SC

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4-Beam Photoelectric Detector
Through-beam laser sensor consisting of a transmitter and receiver. Alarm output has normally open and normally closed contact, up to 250 m outdoor & 750 m indoor detection distance. 13.8 to 24 VDC powered.
SKU: KPR-121 Price: $92.97 + GST

SMS NET Data Logger
It features 8 digital inputs, 4 digital outputs & 8 temp. channels. Configuration is setup by GSM mobile phone or via Ethernet. Up to 10 different numbers can be preset in the system. 9 to 15 VDC powered.
SKU: LEC-050 Price: $699 + GST

DIN Rail Mount Step Pulser
Controls speed & direction of 2 stepper motors. It features on-board potentiometer for speed control, mini joystick for motor run & direction. Output frequency is between 70 Hz to 4.8 kHz. 8 to 30 VDC powered. External inputs for buttons/joystick.
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Wired Glass Breakage Sensor
The sensor is used as an input device to an alarm system. When a glass breakage frequency has been detected, it will trigger a signal to the alarm system. Detection range up to 7 m. 12 VDC powered.
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2.5 mm Universal Terminal
Universal DIN Rail Screw terminal offers a wire section of 2.5 mm2 with 2 side cable entry. Suitable for U type rails, TH35-7.5 & G-type railway G32-15L, G32-18. Other sizes are also available.
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IRTemp Sensor Module
Remote temperature sensing module for your Arduino! It features; on-board voltage regulator, communications interface, measurement temperature range from -33 to 220 °C & 1s response time. 3 to 5 VDC powered.
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DIN-rail mount cyclic timer with configurable on and off times. Features selectable "pulse first" or "pause first" for initial timing function. 4PCO relay outputs, selectable multi-time range from 1s to 100 days. 12 to 250 VAC/VDC powered.
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PRODUCT SHOWCASE

Calling all musos, production controllers . . . anyone who needs a really rugged foot switch

New Zealand based Rixen has released a purpose designed pedal enclosure kit for musical instrument effects.

The pedal is designed to operate either a 3PDT or 4PDT switch as favoured by many guitar effects enthusiasts, and the standard kit includes a high quality 4PDT latching switch with gold plated contacts.

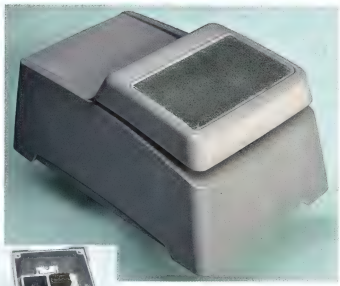
We also think this would be ideal as a run, start/stop or reversing switch for the SILICON CHIP Induction Motor Speed Controller (see last month's issue).

Another feature is an integrated compartment for a 9V battery that can be accessed by simply lifting and sliding open the hinge of the pedal.

Manufactured in New Zealand from sturdy die-cast aluminium, the kit comes complete with all the hardware required to complete an enclosure.

An optional solder masked prototyping PCB makes a complete pedal build easy.

The 139.5 x 89.5 x 69 mm pedal is available in bare aluminium ($USD 36.95), 'Sky Blue' or 'Emerald Green' gloss powder coat ($USD 46.90), Prices exclude shipping.



Contact:
Rixen Pedals Pty Ltd
10 Barlow St, Christchurch, 8041, New Zealand
Tel: (64) 800 555 0100
Website: www.rixenpedals.com

Altronics now stocking Thermaltronics soldering irons

Altronics are now stockists for Thermaltronics soldering stations. The Thermaltronics range features an RF induction design with Curie heat technology. This technology, by Thermaltronics is fast replacing the older conventional ceramic heating element technology by utilizing RF induction to bring the tip temperature to its Curie Point which is set by the composition of a special magnetic alloy. Once it hits its Curie Point, the tip will lose its magnetic properties and will idle at its set temperature ±1.1°C, ready for action in under 10 seconds!

Once the soldering tip makes contact with a solder joint, the tip transfers heat at a rapid rate and when confronted with a heavier load or lead-free solder, the system instantaneously increases its power to ensure constant temperature is maintained at the tip. As the tip is the heater, it responds instantly, unlike conventional soldering systems where users have to dial the temperature right up to compensate for the drop in tip temperature.

Altronics stock two models, the TMT-9000S-2 (pictured) and the TMT-2000S-K station.

Contact:
Altronic Distributors Pty Ltd
PO Box 8350, Perth Busn Centre, WA 6849
Tel: 1300 780 999 **Fax:** 1300 790 999
Website: www.altronics.com.au

Icom tri-band amateur transceiver with touch screen

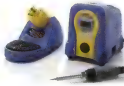
Icom, a leader in amateur radio technology, has announced the release of the IC-7100 touch-screen multi-mode transceiver. With the touch-screen interface, the IC-7100 offers straightforward operation, while the angled display and remote-head configuration make both installation and operation very versatile.

The IC-7100, as a multi-band transceiver, is capable of operating on the HF, 50MHz, 144MHz and 430/440MHz bands. The transceiver also features D-STAR DV mode (digital voice and data), providing digital clarity and security.

With the new optional AH-740 High-Speed Auto Tuning Antenna, operation is even more simplified, especially for mobile use, as the relay-driven tuner automatically adjusts (150ms typical tuning time) when changing frequencies. For more information on the IC-7100 or other Icom products, please visit their website or call the number at right.

Contact:
Icom Australia Pty Ltd
Unit 1, 103 Garden Rd Clayton 3168 Vic.
Tel: (03) 9549 7500 **Fax:** (03) 9549 7505
Website: www.icom.net.au

HK Wentworth putting on a show at ElectroneX



Electrolube Chemicals and Hakko's complete soldering range for Australia and New Zealand region will be on display at Electronex 2013, stand B15. See the new-release FX888D ESD-safe digital soldering station with selectable preset temperatures and digital calibration. It replaces the popular FX888 analog version but still utilises common spares and tips.

The extensive Hakko range of equipment will be on display and available for demonstration.

Electrolube's products on display include conformal coatings, thermal pastes, encapsulating resins, maintenance aerosols and cleaning products. New products will be the Aromatic free conformal coating PUCAF, offering quick cure times and very low VOC's and Isocyanate-free resins PE7500 alleviating OHS concerns.

Contact:
HK Wentworth Australasia
Unit 3/98 Old Pittwater Rd, Brookvale NSW 2100
Tel: (02) 9938 1566 **Fax:** (02) 9938 1467
Website: www.hkwentworth.com.au

See the Latest in Electronics Products & Technology this month at ElectroneX!

ElectroneX – The Electronics Design & Assembly Expo returns to Melbourne this month (11-12 September) at Melbourne Park Function Centre. This specialised event is the major focal point for the electronics industry in Australia and is designed to help professionals across a vast array of industry sectors to stay in touch with the latest electronics technology developments for systems integration and production electronics.

Design, electronic & electrical engineers, OEM, scientific, IT and communications professionals and service technicians are invited to attend the event where they will find the latest technology driving future product & system developments.

ElectroneX comprises a major trade show with over 80 companies showcasing and demonstrating the latest new product releases for industry, scientific and commercial applications. The SMCBA – Electronics Design & Manufacture Conference is being held in conjunction with the exhibition.

This year's conference will feature several highly acclaimed international presenters and deliver a wealth of information on electronics design and manufacture but will also feature new streams on Embedded Systems and New Product Development.

For further information and free trade registration for the expo visit www.electronex.com.au.

ElectroneX
electronics design & assembly expo

New GWInstek 50000 count DMMs

The new generation GDM-834x series dual measurement multimeter from GW-Instek has two models – GDM-8341 and GDM 8342.

Features include 50,000 counts, VFD dual-display, 0.02% basic DC voltage accuracy and a USB protocol connector to provide users with measurement precision, lucid data observation and the convenience to connect with the personal computer.

The GDM-834x series not only supports the fundamental measurement items provided by general multimeter but also has capacitance and temperature measurement functions.

The GDM-834x series can operate alone or can interface to a PC.

Contact:
TekMark Australia Pty Ltd
Suite 302, 18-20 Orion Rd, Lane Cove 2066
Tel: 1300 811 355 **Fax:** (02) 9418 8485
Website: www.tekmark.net.au

Mouser claim world's smallest transistor

ROHM Semiconductor's ultra compact MOSFETs and bipolar transistors, now available through Mouser, have the smallest transistor package on the market.

The VML0806 case type measures just 0.8mm × 0.6mm with a height of only 0.36mm. As portable devices, such as smartphones and digital cameras, get smaller and more sophisticated, thinner, more compact components are required.

Until now, problems related to internal element miniaturisation, bonding stability, package process accuracy, and surface mount technology limited the smallest conventional transistors to the 1006 size (1.0 x 0.6 x 0.37mm). ROHM was able to overcome these challenges by utilizing a smaller element and high-precision package process technology, resulting in a very compact form factor.

Contact:
Mouser Electronics
Unit 702-3, 7/F, LU Plaza, 2 Wing Yip St, Kwun Tong, Kowloon **Tel:** 852 3756 4700
Website: www.mouser.com

Jaycar wants you to find a fortune!

Jaycar Electronics has two new portable metal detectors which they hope will lead you to fortune (if not fame)!

The first (QP-2303) has an LCD readout and will detect a variety of metals including iron, nickel, gold, brass, zinc, copper, silver and aluminium.

It claimed to be able to detect a 10c piece at 150mm depth! This is the deluxe version and sells for $149.00

The second is similar but doesn't have the LCD readout. This one (Cat QP-2301) retails for just $59.95 – you could earn that back in one good (lucky!) day. And this one has a waterproof search coil so you can go prospecting in streams and lakes.

Contact:
Jaycar Electronics (all stores)
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by Ross Tester

Collinear Antennas for ADS-B (or anywhere else!)

In the August issue, Jim Rowe told us that he found the little "toy" whip antennas that come with USB DVB-T Dongles work about as well as anything else for ADSB, especially when cut down to a quarter-wave at ADSB operating frequency (1090MHz). Here are a couple of antennas which will deliver more signal. You can use the same principles for just about any frequency.

A fair amount of research has backed up what Jim said – you don't need a you-beaut antenna to receive ADSB signals.

It was suggested by one source that the reason for this is that the signals, emanating from aircraft and their straight-line, unobstructed paths, are not likely to suffer as much degradation as ground-based signals. That's as good an explanation as we can come up with, too!

However, it was also suggested that there is one antenna type which does offer better performance than a simple quarter-wave whip – and that antenna is the collinear.

The big advantage of the collinear is that it costs peanuts to make, is quite easy to build and should give a useful improvement in gain.

What is a collinear antenna?

These antennas have been around for the best part of a century, having been first described in the jounal of the Institute of Radio Engineers by PS Carter in 1932 and further by CW Harrison in 1945. They have become very popular

I'm holding BOTH antennas in this shot – in my right hand is the little wire antenna, with the much larger coax collinear in my left. There's about 3dB difference between them.

both in amateur and professional ranks over the years.

In a nutshell, a collinear is a vertical antenna whose resonant elements are connected along a common line (ie, co-linear) so that each element is opposite in phase to its neighbour. If you're not into antennas, that mouthful is, fortunately, very easy to achieve.

In some collinears (and the second one we will be making here) this phase transition is achieved simply by reverse-connecting each element. Another approach (especially used in larger, high-frequency collinears) is to use a 1/4-wave phasing stub between each section.

And yet another method is to include an inductor or coil between each section which achieves the same result. There are many other phasing methods as well but we won't get bogged down on the technicalities here. We just want to make an antenna!

Collinear antennas are also very much suited to a limited frequency range – ideal for single-frequency ADSB – and they also have the feature of being very easy to increase the antenna gain, within reason, simply by adding more elements.

The collinears we are describing here are 'end fed' – that is, the feed to the receiver comes from the bottom end of the antenna. This is a very convenient way to feed the antenna, particularly when it is vertically polarised, as it must be for the vertically-polarised ADSB signals.

A properly-designed antenna should be suitable for both transmitting and receiving, so if you want to use the information later in this article to change dimensions and make (say) an antenna suitable for UHF CB radio (476-477MHz) you can easily do so.

Our simplest collinear

As we said earlier, collinears have been around for quite a while and come in all shapes and sizes. Therefore anything we describe here has almost certainly been described elsewhere before. And so it is with this one – in fact, we acknowledge that the whole inspiration came from one we saw on the 'net (http://martybugs.net/wireless/collinear.cgi).

That was for a 6dBi collinear for the WiFi band (2.45GHz); the dimensions simply scale up for the longer-wavelength ADSB frequency.

The beauty of this antenna is that it is made from bits and pieces you may have lying around – the most important one being a length of 2.5mm^2 copper wire.

Hmm, where do you get that from? How about some mains building cable? You'll need the single-strand variety – not quite as common as multi-strand these days – but it doesn't matter if it's old and tarnished. For an 8-element collinear, you'll need a length about 500mm; to add more elements, you'll need more length!

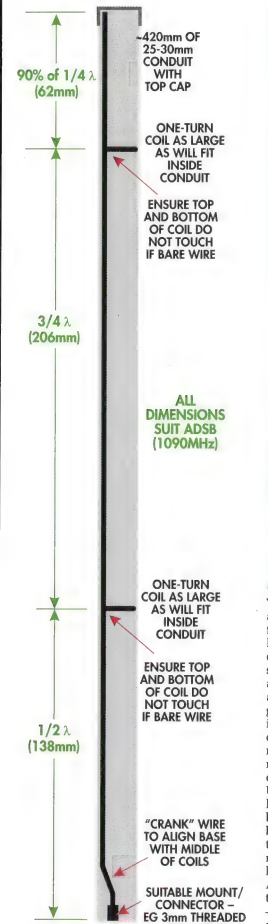
Even if you have to buy a length of this cable, it should set you back not much more than a dollar or so for a metre.

The other hardware you'll need is a length of 20mm or 25mm plastic conduit (again, used in electrical installations – short lengths are regularly discarded from building sites), an end cap to suit (a few cents from a hardware store) and some plastic saddle clamps to mount it (ditto from hardware store).

The easiest way to connect to your antenna is to use the mini base that was supplied with your USB dongle. Admittedly, this only gives you about 1.2m of cable, so if you want to use this over more than that length (outside, for example), you're going to need to make some form of base with low-loss coax to connect to your receiver.

The USB Dongle is likely to have a very small "MCX" connector; so unless you get *really* lucky and find an MCX plug which can fit on your coax, some form of adaptor is likely to be required between the coax cable and the dongle.

But we'd think twice about using this simple antenna and a long length of coax – this one is quick and easy to make but the second antenna should be a better performer.



The simple wire antenna is made from a ~500mm length of 2.5mm copper wire. For such a simple antenna, it gives a surprisingly good result. Above is shown the completed antenna mounted on the mini base which comes with the USB dongle. It's a little misleading as both coils need to be at right angles to the elements, not as the camera has distorted here. And be careful not to bend the wire – it should be as straight as possible.

Before we start

The frequency we want to receive is 1090MHz. This has a wavelength (λ) of 275mm, derived from the formula:

$\lambda = C/f$, where

C = the speed of light (near enough to 300,000,000m/s) and

f = the frequency in Hz.

There are three lengths we need to know, derived from the full wavelength:

a quarter wave (¼λ) = 69mm
a half wave (½λ) = 138mm
a three quarter wave (¾λ)= 206mm
Remember these – you'll need them!

Making the antenna

As Mrs Beeton's cookbook almost says, "first catch your wire!" If you happen to have a length of stiff copper wire, great. Otherwise, you'll need to strip it from a scrap of single-conductor T&E 2.5mm building cable. You don't want the plastic insulation on it, so remove that as well. We worked with a 500mm length.

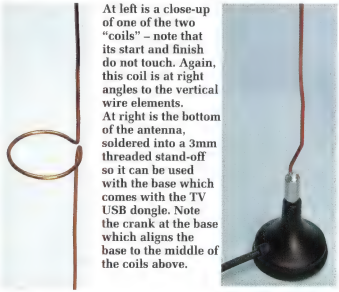
You need to first make the wire as straight as you can – and one of the easiest ways to do this is to firmly grip one end of the wire in a vice, just as firmly grip the opposite end with a large pair of pliers, and pull firmly. You'll feel a little "give" as the wire stretches slightly and presto! A straight length of wire.

Once you've straightened it out, try not to bend it – this will reduce its performance.

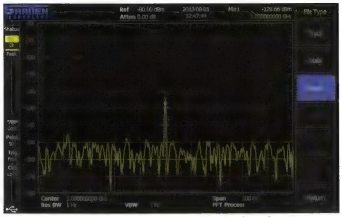
Carefully remove the wire from the vice and cut off any damaged wire (eg, from the vice or pliers) at the end and place it on a flat surface, ready to measure out. As our diagram shows, the wire collinear is in three sections or elements: from the bottom, a ½-wave length, a ¾-wave length and a not-quite-¼-wave length. These lengths are as shown on the diagram. Between each of the elements there is a single-turn phasing coil, wound from the same wire but at 90° to the elements.

You might be wondering why the top element is less than a ¼-wave length.

All antennas exhibit either capacitance or inductance



At left is a close-up of one of the two "coils" – note that its start and finish do not touch. Again, this coil is at right angles to the vertical wire elements. At right is the bottom of the antenna, soldered into a 3mm threaded stand-off so it can be used with the base which comes with the TV USB dongle. Note the crank at the base which aligns the base to the middle of the coils above.



Taken from a Gratten spectrum analyser, this shows a 1090MHz signal received by the bare wire Collinear antenna. As you can see, the signal is well above the background noise and this would be further improved by the coax version of the Collinear.

or both. In this case, it is the capacitance that affects the length, so it is made 10% less than you would normally expect to reduce the capacitance effect and so make the length "seem" like a ¼ wave.

Start at the top of the antenna and measure down, say, 70mm. Mark the wire with a felt-tip pen. Using the photo as a guide, carefully bend the wire straight out at 90° and wind a single-loop coil around a former, as large as will fit into your electrical conduit (20mm conduit is about 16mm ID; 25mm conduit is about 21mm ID).

Note that the start and finish of the coil must not touch each other, particularly if you're using bare copper wire. Also make sure that the start and finish are directly over each other and the coil is as round as you can make it. Now you can carefully measure back up the wire 63mm (69mm - 10%) from the coil and snip off the remainder.

The middle length, down to the next coil, is the ¾ wave length or 206mm. Measure this, mark the wire and bend the second coil the same way as the first, so that the coils are directly under one another.

Finally, the bottom section of the antenna is the 1/2-wave section, 138mm. There is a "crank" in the bottom of this wire so that the bottom of the antenna is in line with the centre of the coils. There's a second wrinkle here: the 138mm must be from the end of whatever you use to mount the antenna. We used the same base that comes with the USB dongle antenna – it has a 3mm threaded end which makes it convenient to use a 3mm (internal) threaded standoff soldered to the wire. Just make sure that you don't push the wire all the way through (leave enough to screw onto the base) and don't fill it up with solder.

djustments

Without some rather specialised equipment, it is not possible to adjust this simple antenna. At 1090MHz, snipping off a millimetre could easily make the antenna not perform properly (by the same token, it could do the opposite. But you have no way of knowing).

So all you can really do is compare this antenna to the ADSB antenna you made by clipping the whip supplied with the dongle down to ¼ wave (69mm). We'd be surprised if it didn't do somewhat better – that is, receive ADSB signals from further-away planes.

Finishing off

The wire antenna is a little prone to damage so it's best housed in some form of protective "case". A short length of electrical conduit is ideal – the whole antenna can be slid inside it with conduit caps to seal it. On the top, the cap slides straight on, whereas the bottom cap will need a hole drilled through it to allow the coax to pass through.

Conduit caps don't tend to fit tight like other PVC pipes, so once everything is finished to your satisfaction (and tested!) we would glue the caps on with either PVC pipe cement (very permanent!) or even a dab of super glue (easier to prise off), just in case you want later access to the antenna.

The web version used a male and female "N" connector but we think this is a bit of overkill – they're not cheap – so why not simply make the coax captive (ie, glue it in) and save the possible losses from the connectors?

The coax collinear

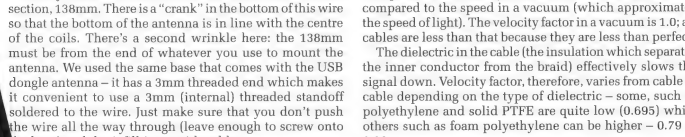
This is the antenna which has been reported as giving excellent results on ADSB – one report we read said that the user could pick up signals from planes as much as 250 nautical miles away (>460km). That's no mean feat – we'd be interested to know if any readers have the same experience.

The coax collinear one is made up of short (approximately ½ wavelength) lengths of coaxial cable, secured together so that the inner conductor of one length connects to the braid of the next and vice versa. This gives the necessary phase reversal of each element.

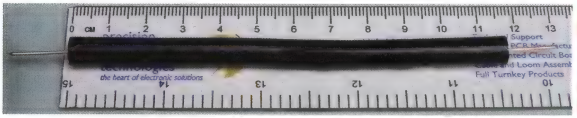
The reason we said ~1/2 wavelength lengths of coax is that there is a slight complication factor here. All coaxial cables exhibit what is known as velocity factor, which is the speed an electromagnetic wave travels along the cable compared to the speed in a vacuum (which approximates the speed of light). The velocity factor in a vacuum is 1.0; all cables are less than that because they are less than perfect!

The dielectric in the cable (the insulation which separates the inner conductor from the braid) effectively slows the signal down. Velocity factor, therefore, varies from cable to cable depending on the type of dielectric – some, such as polyethylene and solid PTFE are quite low (0.695) while others such as foam polyethylene can be higher – 0.79 to 0.88.

What this means to the constructor is that the length of the elements in the collinear need to be adjusted to take the velocity factor into account, simply by multiplying the theoretical half wavelength (in this case @ 1090MHz =



Here's one element of our coaxial collinear, shown exactly same size so you could even use this as a template. Shown at left is a typical "quad core" coax cable, with the layers cut to reveal its construction.



We found it easiest to mark off the elements by using a rule. The length of centre conductor (copper wire) emerging from each end is not at all critical – just long enough to work with – but the length of the element itself is! As seen here, we cut each element to 117mm. You need to end up with a clean cut as shown at right – make absolutely certain there are no wisps of wire shorting between the centre conductor and braid. If necessary, check for shorts with a multimeter.

138mm) by the velocity factor. For a foam dielectric collinear, this would be 117mm (138 x 0.85).

If you have a coax with clear identification, there are many references on the net which will tell you its velocity factor. If you can't identify it, look at the dielectric: if it is foam, use the 0.85 figure. If it is solid, use the 0.695 figure.

Because the receiver input is 50Ω impedance, you should ideally use 50Ω coax. But we've made ours from RG6 coax (because we had some) which is 75Ω, so if you happen to have a spare length of 75Ω, give it a go. Sure, it's not quite according to Hoyle – but you won't break anything!

How many elements?

This is entirely up to you! While there would be little point in making a one-element collinear, it can be done. But theoretically, the more elements there are the more gain your antenna will have (doubling the number of elements should give you a 3dB increase in gain). However, there is a law of diminishing returns as there are losses (in the coax) which start to become significant fairly quickly. 8-12 elements appears to be about optimal both from a performance viewpoint and also ease of construction and stability.

A collinear with 12 elements at 1090MHz will have a gain of about 6dB and be just over 1.4m long, which is probably a good compromise between gain and size. If you're stuck for space, 8 elements should still give a reasonable performance and be less than 1m long.

Construction

There are several options available here – we'll look at just two of them. The first is arguably the more "permanent" arrangement, and that requires soldering the elements together. The downside of this is that it is quite easy to damage or distort the dielectric, especially if it is foam, which can degrade performance.

It is essential that new, unweathered coax cable be used for this method because you need the solder to take to both the braid and centre conductor very easily and quickly.

The second method doesn't need soldering but relies on a "friction fit" connection between centre conductor and braid, held in place by the coax cable's outer insulation. While this works well for a time, we'd be inclined to think that eventually corrosion or weathering will make the connection between the sections at best problematic. Still, it's a quick and easy way to make an antenna and has many supporters on the 'net.

Cutting the coax

You'll need some nice, straight coax so if it has been wound on a drum or coiled, it will need to be unwound

You *can* cut the coax with a very sharp hobby knife (be warned, the blade will be blunted) but one of these rotary strippers makes the job so much easier.

and straightened for some time. Pulling it tight will help straighten it. Even then, it will have a tendency to curl back up again.

It's a lot easier to work with small sections of coax so cut as many lengths as elements you want, perhaps 150mm in length – that gives you the 117mm element length required plus about 15mm or so of inner conductor to join to the next element.

Carefully remove the outer insulation, braid and inner insulation (dielectric) from each end, leaving the inner conductor poking out, so that you are left with lengths measuring 117mm from insulation end to insulation end. A sharp hobby knife can be used to cut coax and/or remove insulation and braid but a rotary coax cutter makes this job a lot easier and repeatable - but just be careful that you get those lengths right.

And before you move on to the next sections, check the

Here's what you want to end up with: 1' identical lengths of coax cut to size an assembled.

cut ends with a multimeter and/or a magnifying glass/loupe. It's far too easy to leave strands of wire which might short between the braid and centre conductor, rendering your antenna useless.

You should end up with absolutely identical lengths of coax as shown in our pictures.

The next step depends on which of the two methods above you're going to use.

(a) Soldered collinear

This is not our preferred model, as soldering to co-ax braid is not as easy as you might imagine. This is particularly so if (a) the braid is at all weathered or oxidised or (b) if the outer braid is actually woven aluminium – that's very hard to solder to without special fluxes and solder. But it can be done!

Remove another 10mm of outer insulation (only) from each end of each of the prepared lengths, being careful not to cut the braid underneath. Cut all the centre conductors to 10mm. It will pay you to pre-tin all centre conductors and a 'strip' along the braids, making sure the tinning is on the same side as each other.

It's also easiest to make a jig to solder the sections of coax together because you need to ensure they go together (a) in a 'stepped' straight line (see photo and diagram); (b) with their ends actually touching each other, as long as the braids and conductors aren't shorting and (c) so that they soldered elements are as mechanically rigid as possible. Our photos should help explain this.

Repeat for all the elements (coax sections) but for the top-most element, simply clip off the centre conductor so it cannot short to the braid.

The bottom element connects directly to the coax lead-in (to your receiver) in the same way as the rest of the elements connect to each other.

Because you now have a number of exposed solder joints, cover with some self-sealing adhesive tape to minimise oxidation and corrosion.

This antenna needs to be housed a plastic conduit, just like we did the wire collinear above. Simply follow those details to weatherproof your coaxial collinear.

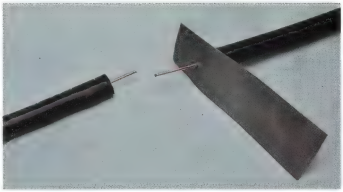
(b) "Friction fit" collinear.

This is our preffered antenna because very little soldering is involved.

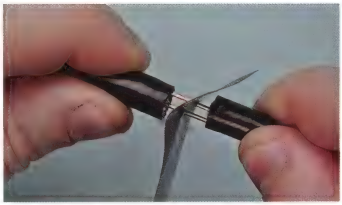
Prepare your elements in the same way as you did for the soldered model but don't remove any extra outer insulation – that is, the insulation, braid and inner insulation should all be cut off cleanly, leaving the inner conductor exposed. Shorten the centre conductors to about 10mm.

Cut a 75mm length of insulation tape and push one conductor through the centre of the tape, close to one end. Take the second element and push its centre conductor through the tape from the opposite side about 3mm away from the conductor already pushed through. Again, see the photos to view this.

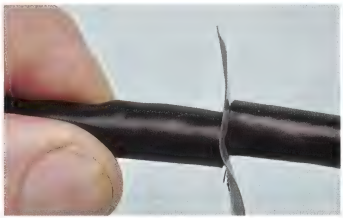
Now you have to carefully slide both centre conductors between the outer insulation and the braid of the opposite element. It may pay you to warm the outer insulation first – say with a hair drier – if you have problems doing this. Push the two elements together as far as they will go then secure them in position using the insulation tape. As well as holding the elements together, the tape prevents shorts



Slide a length of insulation tape over one of the centre conductors. The tape is to prevent the two braids shorting out when the elements are brought together.

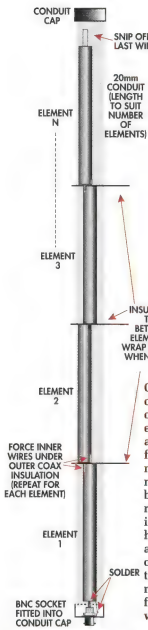


Then pass the other centre conductor through the tape as you bring the two elements together. Slide the centre conductor from one between the outer insulation and braid of the other . . . and vice versa.

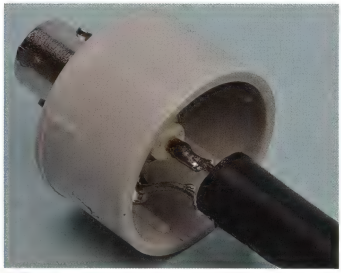


Continue pushing the two elements together until they touch. You can see that they are slightly offset one to the other and the tape forms an electrical barrier between them.

Finally, wind the excess tape around the join to hold the two elements together. You can relax – just as soon as you've finished another 11 elements . . .



Our "friction fit" collinear – we've only shown four elements but we actually made it from twelve. Any more than this will not give appreciably better results. At right is the antenna, inside its conduit housing, secured to a pipe with a couple of hose clamps. Lash the coax to your receiver to the pipe for security against wind damage.



Drill out a conduit end cap to accept a BNC connector and solder its centre pin to the bottom element conductor. Force a short length of wire between the insulation and braid, and solder that to the BNC connector earth lug. These caps (top as well) will need glueing to the conduit as they are invariably a loose fit.

between the braids of the two cable sections.

Repeat these steps for as many elements as you have, as well as the coax lead-in to your receiver. Once again, snip off the centre conductor from the top wire.

Mount the antenna in a suitable length of electrical conduit as per the wire collinear above.

We mounted ours via a pair of worm-drive hose clamps on a length of water pipe so its base ends up about 2-3m above ground level. It would appear that the higher above ground the antenna is erected, the better the performance. However, that means a longer coax lead in with its own losses at 1090MHz, so you might need a little experimenting to find the "sweet spot" of height vs loss.

And that's it: two different collinears which will offer better performance for ADSB reception than a simple whip. Now if you want to make a collinear for a different frequency, read on . . .

Making a collinear for other frequencies

The above steps can be used to make coax collinears for any frequency or band you want to listen to. We've seen them made for UHF CB, for 2.4GHz WiFi, for VHF amateur frequencies (2m, 6m, 70cm, etc) . . . we've even seen one monster made for the 20m amateur band, hanging from a *very* tall tree!

Naturally, physical constraints come into play with lower frequencies – a 12-element coax collinear for the 80m amateur band might be just a bit of a stretch (It would be a bit over 500m high!).

Simply remember that formula: wavelength = 300,000,000/frequency (Hz) [in metres]

So for that 20m (14MHz) amateur band collinear, the wavelength would be 300,000,000/14,000,000 or 21.42m and each element (½ wave) would therefore be 10.71m long. From memory, it had four elements so was over 43m high.

Other common wavelengths:

WiFi band	(2.45GHz)	= 122mm
UHF CB band	(476MHz)	= 630mm
70cm amateur band	(say 430MHz*)	= 680mm
2m amateur band	(say 146MHz*)	= 2050mm
Aircraft band	(say 125MHz*)	= 2400mm
FM broadcast band	(say 100MHz*)	= 3000mm
6m amateur band	(say 53MHz*)	= 5660mm

For other frequencies you might want, simply use the formula shown earlier. Remember, these are full wavelengths – multiply by 0.5 to get 1/2 wave element length, by 0.25 to get a 1/4 wavelength and of course by 0.75 to get a 3/4 wavelength.

* We have nominated frequencies which are either in the middle of the band or where much of the action is located. (EG, aircraft band is 108-136MHz but voice communication is mostly towards the upper end of the band). SC

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- 20:1 Distance to spot ratio
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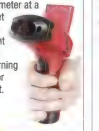
QM-7211

NEW $119.00



DVD/CD Player with 5 Disc Changer

Features a 5 DVD/CD changer which enables to load 4 discs while the other one is playing. It also has a Karaoke CD+G function, two microphone inputs with individual level controls and a USB, SD/MMC card reader for complete playback flexibility. Mains powered.

- Formats: AVI, DIVX, MPEG2, MPEG4, WMA, DAT, VOB, MP3, WAV
- Mains powered
- Size: 496(L) x 416(W) x 152(H)mm

AA-0489 *was $349.00*

$299.00 SAVE $50

Limited stock. Not available online.

Network 4 Channel DVR Kit with 4 High Resolution Cameras

Digital Video Recorder with high resolution 600TV line cameras which can record video constantly, scheduled, when motion is detected or alarm triggered. Composite and VGA output for local viewing, and an Ethernet connection which can be configured for remote viewing using a web browser or iPhone®/Smartphone free app. Supplied with 500GB HDD to record up to 300 hours of continuous video, 18m cables, mouse, remote control and power supply. See website for full specifications.

- D1 resolution (704 x 576) on each channel
- H.264 video compression
- Includes 4 colour weatherproof CMOS 600 TV Line cameras

QV-3032 *was $649.00*

Monitor also sold separately QM-3577

Add this 17" Monitor for $150 (QV-3102)

$599.00 SAVE $50

4CH DVR KIT (QV-3032) + 17" Monitor (QM-3577) = $749 WINNING DEAL!!!

12V Handheld Spotlight

40,000 Candle power 12V spotlight, features 44W Halogen bulb. Comes with an adjustable handle and a 3m curly cord with cigarette lighter plug.

- Water resistant
- Size: 120(W) x 195(L) x 171(H)mm

ST-3266

NEW $14.95

See Instore for LED Spotlights

TOOLS FOR THE WINNING DAD

Meters

Economy Non-Contact Thermometer

Safely measure temperature in hot, hazardous, or hard to reach places with the built-in laser pointer directed at the surface. Provides several readings within seconds. Compact and easy to use with carry case included.

- 8:1 Distance to spot ratio
- Temperature range: -30°C to +260°C (-22° to +500°F)
- Size: 131(H) x 96(W) x 35(D)mm

QM-7215

$49.95

Digital Sound Level Meter

Measures sound levels between 30 to 130dB and can be set for fast or slow responses. Includes data hold and min/max functions, as well as tripod mount. Supplied with carry case and wind sock.

- 210(L) x 55(W) x 32(D)mm

QM-1589

$99.00

True RMS AC/DC Clamp Meter

This meter will read up to 1000A AC or DC. Ideal for electrical fitters and contractors working with high currents. See website for full specifications.

- 6000 count, Cat III 600V
- Autoranging
- Jaw opening: 40mm
- Size: 230(H) x 76(W) x 40(D)mm

QM-1566

$139.00

Universal Drill Press Stand

Convert your standard power drill or rotary tool into a drill press with this adjustable stand. Built-in press depth gauge for accurate drilling and adjustable limiting brace.

$29.95

- Drilling depth: Up to 60mm
- Size: 497(H) x 350(W) x 160(D)mm

TD-2463

Electric Screwdriver - 18 bits

Features a comfortable moulded grip, reverse and forward modes, an LED to illuminate hard to see spots, and carry pouch. The drill has three adjustable configurations from the traditional gun style to a cylindrical shape for applying extra pressure on stubborn screws or bolts.

- Mains charger included
- Size: 270(L) x 45(W) x 37(D)mm

TD-2497

$19.95

Father's Day Giveaway

FREE Spirit Level Keyring (TH-1931) **with every purchase over $50.00**

While stocks last.

Long Bit Screwdriver Set

Tackle a wide range of fastening scenarios using our compact screwdriver set comprised of a selection of popular slotted, Phillips, Star and TRI bits. See website for contents.

- 22-piece

TD-2114

$29.95

Thread Repair Kits

These thread repair kits will enable you to drill out a stripped or otherwise damaged thread in a blind hole. Available in M3, M4, M5 and M6 sizes. 10 inserts included in kit.

M3 Threads	HP-1600 $24.95
M4 Threads	HP-1602 $24.95
M5 Threads	HP-1604 $24.95
M6 Threads	HP-1606 $24.95

NEW $24.95 EACH

Wireless Thermometers

In & Out LCD Thermometer

Keep an eye on the outdoor and indoor temperature with ease. This thermometer is comprised of two parts. An LCD display/receiver to keep inside and a wireless outdoor temperature sensor which transmits the outdoor temperature back to the display.

- Requires 4 x AAA batteries
- Receiver size: 86(H) x 57(W) x 18(D)mm
- Sensor size: 68(H) x 50(W) x 21(D)mm

XC-0321

NEW $19.95

8 Channel Thermometer/ Hygrometer with Jumbo LCD

Useful for monitoring temperature and humidity sensitive areas. Displays real-time data, comfort and trend indicators and stores min/max records. Can support up to 8 indoor/outdoor sensors.

- Requires 6 x AAA batteries
- Size: 94(L) x 94(W)mm

XC-0328

NEW $39.95

Spare sensor to suit also available XC-0329 $17.95

Non Contact Thermometer with Smartphone App

This non-contact thermometer uses infrared radiation to instantly and accurately measure both body temperature and surface temperature. It can also link to your Smartphone with a free App to track temperatures on a calendar, assist with planning pregnancy, and much more. See our website for info on the app.

- Temperature range: 0-50°C (32°F - 122°F)
- Basic accuracy: ± 0.3°C
- Size: 145(L) x 57(W) x 35(D)mm

QM-7201

NEW $89.95

Hand Tools

Long Nose Pliers

Made of high quality stainless steel, these pliers have half round smooth gripping jaws perfect for adjusting and bending components, picking up dropped nuts etc. Comfortable spring loaded handles.

- 145mm long

TH-1893

WINNING DEAL! BUY 2 for $20 SAVE $7.90

$13.95

Phillips Screwdrivers

This range of quality insulated screwdrivers features an ergonomic handles with a soft rubber coating for a secure, comfortable grip. TUV and GS approved and rated up to 1kV.

- A size for any application

Phillips #0 x 60mm	TD-2235 $4.95
Phillips #1 x 80mm	TD-2236 $5.65
Phillips #2 x 100mm	TD-2237 $6.95
Phillips #3 x 150mm	TD-2238 $7.45

Slotted Flat Blade screwdrivers also available. Ask in-store or visit website.

FROM $4.95

Sheet Metal Bending Pliers

Bend sheet metal easily with this heavy duty offset hand tool. Features strengthened rivets and dual layered pitted handle for a firm grip.

- Jaw width: 75mm, Jaw depth: 30mm
- Overall length: 210mm

TH-2336

$24.95

Ratchet Crimping Tool for F-Type Connectors

A strong, heavy duty tool for crimping F-Type CATV connectors onto RG6 or RG59 coax cable. Ideal for cable TV or RF distributions system installers.

- Secure ratchet mechanism

TH-1831 *was $39.95*

$29.95 SAVE $10

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/09/2013.

DIY FOR THE WINNING DAD

Home Security
8 Zone Wireless Alarm Kit

Everything you need to get a basic wireless system set up in your home! Includes a key fob remote control, backlit LCD control panel, PIR sensor and two reed switches.

$129.00
SAVE $20

- Back-up battery
- Size: 210(L) x 113(W) x 127(H)mm

LA-5145 *was $149.00*

See online for our full range of spare accessories.

Slimline Colour 7" LCD Video Door Phone

Screen your visitors without even going to your door. A high resolution viewing screen allows you to see who is at the door, while the intercom allows you to have a two way conversation. For added security you can lock or unlock your door with one touch (door locks available separately) and even use it as an alarm system. Easy to install.

$179.00
SAVE $20

- 7" TFT LCD screen
- CCD camera 420TVL
- Infrared for use at night
- Power supply included
- Monitor size: 235(L) x 165(H) x 24(D)mm

QC-3608 *was $199.00*

Limited stock. Not available online.

portasol® Super Pro Gas Soldering Tool Kit

This quality kit contains a Portasol® Super Pro Gas Soldering Iron featuring 90 minute run time, 10 second fill, maximum 1300˚C temperature and 40 second heat up. Cordless freedom.

$159.00

- Includes 2.4mm & 4.8mm double flat tips, hot air blow, hot knife tip & air deflector, storage case & cleaning sponge

TS-1328

Soldering Iron Starter Kit

The ideal starter package for electronics enthusiasts or the home handyman, this kit contains everything needed for working on basic electronics projects or automotive circuits. Includes a digital multimeter, soldering iron, de-soldering tool, screwdrivers, pliers and side cutters.

$34.95

- 25W

TS-1652

Heatshrink Assortment Trade Pack

Contains 160 lengths of different sizes from 1.5 to 10mm in black, red and clear in a handy storage case.

- Case size: 205(L) x 110(W) x 35(H)mm

WH-5524

WINNING DEAL!
BUY 2 for $39
SAVE $9.90

$19.95

Tool Set Repair Kit for iPhone®

This tool kit allows you to disassemble and re-assemble your phone for replacing cracked screens, dead batteries, scratched back panels and more. See website for contents.

- Suits iPhone® 3G, 3GS, 4, 4s, 5

TD-2115

iPhone® not included

NEW
$14.95

DUE EARLY SEPTEMBER

Professional Laser Distance Meter

A professional grade laser distance meter allows you to easily measure the distance between two points, it can calculate the area of a rectangle, the volume of a room, or the height of a wall thanks to the in-built Pythagoras calculator. Can store up to 20 measurements for quick referral and features an illuminated screen for use in the dark.

- Up to 35m range
- Requires 2 x AAA batteries
- Size: 110(L) x 45(W) x 27(H)mm

QM-1622

Also available:
Professional Laser Distance Meter with Smartphone App NEW
QM-1624 $209.00 DUE MID SEPTEMBER

NEW
$129.00

Mini Tap & Die Set

This 31 piece set is for the ultra small screws found in electronics. Consists of 9 metric screw cutting dies and 18 equivalent taps in the same sizes but with a taper and a plug version of the tap. Supplied in a see-through plastic case.

- Size: 83(W) x 153(L) x 12(D)mm

TD-2443

NEW
$59.95

Automotive Crimp Tool with Connectors

The tool will cut & strip wire, crimp connectors and also cut a range of metric bolts. Every car enthusiast should have one of these.

- Includes male & female bullet & spade connectors + eyes and butt joiners.

TH-1848

$13.95

12V Rotary Tool Set

Drill, saw, sand, polish, carve or grind with this comprehensive rotary tool set. Rated 12V and runs at 12,000 RPM and with over 100 bits and attachments you'll be able to cover every task imaginable.

- 110 piece
- Case size: 240(L) x 200(W) x 70(D)mm

TD-2451

$29.95

Solar Powered Entry Chime

Attach the wireless IR detector at the entrance & be alerted of customers or guests as they enter and leave your premises. Installation is easy, the detector runs on 4 x AAA rechargeable batteries and is topped by the solar panel charger included. The wireless receiver can be wall mounted, placed over the counter, desk or wall mounted with no messy wiring connections in between.

- Transmission range up to 100m
- IR detection range: 2 - 6m
- Detector size: 71mm high, Annunciator size: 143mm high

LA-5176

$99.00

Party
DMX LED Moving Head Spotlight

Compact, lightweight and cost effective. Integrates a user selectable 540º pan and 270º tilt, it has 9 gobos plus open and wheel spin effect. With 14 DMX channels, it features variable electronic strobe and dimmer functions.

- 15W RGBW LED light
- Mains powered
- Size: 249(H) x 173(W) x 173(D)mm

SL-3440

$299.00

DMX Powered Laser Beam

This model features an XLR out plug that allows you to daisy-chain multiple units together for full DMX controlled visceral ambience. Mount to your speaker stand or other frame work with the supplied bracket.

- Laser colour: red, green & yellow
- Sound control: Auto, DMX 512 (7 channels)
- Mains powered
- Size: 363(L) x 143(W) x 67(H)mm

SL-3451

NEW
$199.00

19" Rack Mount DMX Controller

Control multiple DMX devices, such as lights, dimmers, fog machines or laser shows with preprogrammed scenes such as fade, pan, strobe, colour etc. Rack-mountable and mains powered.

- Control up to 12 devices
- 16 channels per device
- 9V plugpack included
- Size: 482(W) x 133(H) x 70(D)mm

SL-3429

$149.00

Reversing & Side-View Cameras

Vehicle Side View/Front View Cameras

The camera is inside a low profile rubberised housing only 20mm high with high-quality 3M brand double-sided adhesive tape to permanently stick the cameras in place. A special wedge is supplied for each unit to get the view angle right. Ideal for caravan use or for any vehicle and has night vision capability. Kit comes with a left and right camera with power leads (12V) and coaxial video leads.

- Waterproof
- 150° viewing angle
- Size: 70(W) x 38(D) x 24(H)mm

QC-3521

NEW
$99.00
DUE MID SEPTEMBER

Mega Wide View Rear Vision Camera

This unit gives you a mega wide 180° viewing angle instead of the usual fish eye. Simply mount on any flat surface through an 18mm hole (hole saw bit is supplied). Water resistant IP68 rated camera.

- Will work as all round side view camera
- Size: 22(Dia.)mm including bezel

QC-3520

NEW
$119.00
DUE MID SEPTEMBER

Auto Shutter Reversing Camera

Ideal for trucks, buses and caravans, however can be mounted behind a rear windscreen with the shutter disabled. Shutter opens when it senses +12V from your reversing lights. Equipped with a black metal shutter to protect the unit from flying stones etc. IP68 rated.

- 120° viewing angle
- 12VDC power
- Size: 78(W) x 65(H) x 60(D)mm

QC-3522

NEW
$199.00
DUE MID SEPTEMBER

Portable Car Safe

Perfect for keeping Dads mobile phones or GPS's safe while parked. Secure under the seat or in the boot of your car with the included alloy cable strap.

- Weight: 1.3kg
- Size: 210(L) x 150(W) x 68(H)mm

HB-5455 *was $24.95*

$19.95
SAVE $5
Contents not included

LCD Alcohol Tester

Don't get behind the wheel if you're over the limit. Test yourself first with your own breathalyser. It takes a reading in less than five seconds and can sound an alarm at a preset level.

- Accuracy of .04mg/L
- Backlit LCD
- Requires 3 x AAA batteries

QM-7296

WINNING DEAL!
FREE
Replacement Mouth Pieces Pk10 (QM-7257) WORTH $8.95

Please note: this product is intended to give an indicative reading only and is carries no guarantee of accuracy. Jaycar accepts no responsibility for any consequence arising from the use of this device.

Replacement mouth pieces pk10 also available QM-7297 $9.95

$49.95

Digital Tyre Pressure Gauge

Keep track of tyre pressure and avoid pressure related problems. Measures pressure from 5 to 100PSI and includes an integrated torch for night time use.

- Includes 2 x AAA batteries
- Size: 156mm long

QP-2293

$14.95

Rechargeable UHF Transceiver

Features a built-in LED torch to read maps in the dark whilst out in the bush. It does all the normal CB functions and includes a desktop charging cradle, AC adaptor, two transceivers and batteries.

SAVE $5 A PAIR!

- 80 channel
- Power output: 0.5W
- Up to 3km range

DC-1009

$69.95 PAIR

Car Battery Monitor

Check the voltage output of a car's battery quickly and easily. Simply plug this handy voltmeter into the cigarette lighter socket and get an instant readout.

- Display resolution: 0.1V
- Operating voltage: 8 - 28VDC

QP-2220

$19.95

In-Car Sound! RESPONSE

Our ever popular Response Precision Kevlar Coaxial Speakers that has won many awards and magazine recommendations. The speaker cone is supplied in black and the soft dome tweeters provide clean, crisp sound and maintains a natural and smooth balanced sound.

- Sold as a pair

2 Way 4" 40WRMS
CS-2400 $69.95

2 Way 5" 50WRMS
CS-2401 $79.95

2 Way 6" 75WRMS
CS-2402 $89.95

2 Way 6 x 9" 75WRMS
CS-2403 $119.00

FROM $69.95 PAIR

CS-2400

CS-2403

Can-Sized Inverter

Designed to fit perfectly into Dad's car drink holder. Ideal for providing mains power without the space or mounting requirements of a full size inverter.

- 12V, 150W
- Modified sine wave
- Size: 130(L) x 60(Dia.)mm

MI-5121

Limited stock. Not available online

$24.95

5-in-1 Jump Starter

Your personal roadside assistant! Includes heavy duty insulated jumper leads, a 400W inverter, LED work light, 12V power outlets, status gauges, and even a 260PSI air compressor! Powered from the built-in 18Ah SLA battery and comes with mains and 12V charging cables.

- Size: 220(L) x 215(W) x 295(H)mm

MB-3594 *was $149*

$119.00
SAVE $30

Car Essentials!

Play MP3 Music Over your Car Stereo

Simply plugs into a cigarette lighter socket and will play audio tracks from a SD/MMC card, USB flash drive, iPod®, or MP3 player directly through the FM band on the car stereo.

WINNING DEAL!
BUY 2 for $20
SAVE $9.90

- Includes a remote control
- Size: 130(L) x 40(W) x 25(H)mm

AR-3120

$14.95

Suction Mount Bracket for Smartphones

Extremely strong suction mount joined to a tough flexible gooseneck. Suits a wide variety of Smartphones so you can access your phone while in your vehicle. The cradle can be rotated for portrait or landscape view.

- Size: 235(L) x 84(W)mm

HS-9030

$19.95

iPhone® not included

Car Power Extender with Phone Holder

Sits in the vehicle's cup holder and doubles the cigarette power sockets and provides two USB ports to power two gadgets at once. A perfect accessory for Dad's car!

- 12VDC
- 1.6m long curly cord
- Size: 100(L) x 70 (Dia.)mm

PS-2122

$24.95

Accessories not included

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/09/2013.

Mains Power

Mains Surge Protectors

These two mains surge protectors alleviate the majority of problems caused by spikes and surges in voltage which can damage delicate and expensive appliances connected to your power outlets. Each model has three-way protection across active-neutral, active-earth and neutral-earth and is fully approved for electrical safety.

- 240VAC 50Hz 10A

Single Power Point & Phone
MS-4017 $12.95

Double Power Point
MS-4015 $10.95

FROM $10.95

IR Controlled Wireless Mains Sockets

These wireless sockets can be programmed and assigned to an unused button on a TV or other remote control to turn them on and off. Allows multiple sockets to be controlled from the one button or assign one button per socket. Includes IR receiver units and 2 wireless mains sockets.

- Up to 20m range
- 10A, 2400W rated

MS-6158

$39.95

Spare Wireless Mains Socket MS-6157 $14.95

USB Mains Power Adaptors

Charge an array of mobile phones, Tablets, or MP3 players with ease. With 2.1A output current, it will comfortably charge a Smartphone, iPad® or other Tablet at full speed. Worldwide voltage input makes it ideal for travellers. Lead not included.

NEW FROM $19.95

- Input voltage: 100-240VAC, 50/60Hz

2.1A
- Output: 5VDC, 2.1A
- Size: 58(W) x 54(L) x 35(H)mm

MP-3456 $19.95

2 x 2.1A
- Output: 5VDC, 2.1A + 2.1A (4.2A total)
- Size: 60(W) x 60(H) x 30(D)mm

MP-3459 $24.95

12V & 24V Power

NEW Pure Sine Wave Inverters

These new inverters provide standard protection as well as host of additional features to improved performance and reliability under adverse conditions, including a soft start feature to reduce inverter overload when used on large appliances. All models include a standard 230VAC mains outlet and a USB port for powering and charging USB devices. See the website for full specifications.

12V 180W	MI-5700	$189.00
12V 360W	MI-5702	$229.00
12V 800W	MI-5704	$399.00
12V 1500W	MI-5708	$849.00
12V 2000W	MI-5710	$1099.00
24V 2000W	MI-5712	$1099.00

NEW FROM $189.00

9-Stage Switchmode Battery Charger

WINNING DEAL! BUY MB-3608 & GET MB-3603 FREE worth $49.95

Nine step fully automatic 25A high current charger with maintenance charging of all types of lead-acid batteries (SLA, Gel and AGM) as well as lead-calcium batteries from 50 - 500Ah, either 12V or 24V. The electronics are fully microprocessor controlled and protected against user error, so is totally safe to leave connected for months at a time. Perfect for caravan and boat users. See our website to download full product info sheet.

$399.00

- IP44 Rated
- Size: 260(L) x 135(W) x 70(H)mm

MB-3608

Also available:
3-Stage 6/12V Automatic Battery Charger MB-3603 $49.95

MB-3603

Dual Battery Volt/Current Monitor

This digital battery monitor will check your main battery voltage and the total battery activity of your auxiliary battery. Excellent for boats or caravans/RVs, especially when running refrigeration products. 250A current shunt supplied.

- Front panel size: 72(W) x 65(H)mm
- Mounting hole: 2" or 52mm

MS-6176

NEW $149.00

Rechargeable Automotive Work Light

A functional 200 lumen work light no motor enthusiast should be without. Affix to any metallic surface via magnetic base and back. Adjust direction of light using multi-position stand. Use it like a torch or hang it off your car bonnet.

- Rechargeable Lithium battery
- 3 x 1W CREE® LEDs with optical lens for better focus
- Size: 280(L) x 62(W) x 44(D)mm

ST-3261 *was $59.95*

$49.95 SAVE $10

Rechargeable CREE® XML Spotlight with Digital Display

A powerful spotlight that will output up to 550 lumens thanks to the new efficient CREE® XML LED. Features a digital readout to show remaining burn time and dual swivel handle. Mains and car cigarette lighter plug chargers included.

- 2 x LED map reading light
- Size: 285(L) x 166(W) x 197(H)mm (folded)

ST-3314

$69.95

Intelligent Battery Charger

Charge and maintain 12V batteries with this microprocessor controlled charger. Features reverse polarity protection, overheat protection, voltage compensation, fan cooling and more. 5 stage charging (soft start, bulk charging, absorption, float and pulse).

- Suits WET/Flooded, GEL, AGM, MF, VRLA, Calcium type lead acid rechargeable batteries
- 12V 10A
- Size: 230(H) x 170(W) x 140(D)mm

MB-3625

$99.95

Give Dad a Jaycar Gift Card this Father's Day

Home Lighting

LED downlights have a lot of benefits over their traditional halogen counterparts, the biggest of which are their significantly lower power consumption (around 70-90% less), longer life expentancy (50,000 vs 2,000 hours) and significantly lower heat generation. Featuring 24 of the highest output 2835-type SMD LEDs, they put out over 450 lumens of warm white or cool white light with either 120° or 60° beam. Installation is easy as replacing a globe. Ideal for caravans and mobile homes, household lighting, shop fittings, or anywhere a bright downlight is required.

MR16 LED Downlights

- 12VAC/DC, 4W
- MR16 24 x 2835 SMD LED

120° Cool White	ZD-0540	*was $19.95*	*now $14.95 save $5*
120° Warm White	ZD-0541	*was $19.95*	*now $14.95 save $5*
60° Cool White	ZD-0542	*was $19.95*	*now $14.95 save $5*
60° Warm White	ZD-0543	*was $19.95*	*now $14.95 save $5*

FROM $14.95 SAVE $5

GU10 Mains LED Downlights

- 240VAC, 4W
- GU10 24 x 2835 SMD LED

120° Cool White	ZD-0544	*was $19.95*	*now $14.95 save $5*
120° Warm White	ZD-0545	*was $19.95*	*now $14.95 save $5*
60° Cool White	ZD-0546	*was $19.95*	*now $14.95 save $5*
60° Warm White	ZD-0547	*was $19.95*	*now $14.95 save $5*

FROM $14.95 SAVE $5

TECH GADGETS FOR THE WINNING DAD

Portable Speakers

Near Field Audio Wireless Speaker

Place your Smartphone or iPod Touch® on top of this speaker to wirelessly amplify the music playing from its loudspeaker. Powered either by batteries (not included) or via USB.

- Output: 2 x 2WRMS, 1 x bass booster
- 5VDC power in
- Size: 155(L) x 71(W) x 38(H)mm

XC-5220 iPhone® not included

$39.95

Portable Mini Speaker

Rechargeable amplified stereo speaker that connects to an iPod®, iPad®, MP3 player, Smartphone or computer. It can also play a microSD card full of music files. Internal Li-ion battery recharges via USB.

$39.95

- Output: 3 + 3WRMS
- Size: 74(L) x 50(W) x 52(H)mm

XC-5176 iPhone® not included

Mini Portable Bluetooth® Speaker System

Take your music anywhere with this rechargeable Bluetooth® mini portable speaker system. Don't let its lightweight design and size fool you: It produces quality sound! Includes Bluetooth® connectivity and a 3.5mm auxiliary port for universal connection.

- Stream music wirelessly from any Bluetooth® music player
- Answer phone calls wirelessly from any Bluetooth® smartphone
- Built-in rechargeable battery
- Size: 53(L) x 168(W) x 38(H)mm

XC-5207

iPhone® not included

NEW

$59.95

Also available: ***Bluetooth® Speaker System*** XC-5206 $69.95

Outdoor USB Solar Charger

Provides a 5V USB port suitable for charging devices such as Media Players and Smartphones. Attach it to a backpack, tent, or bike using the elastic strap and clips to charge on the go.

- Output Voltage: 5VDC
- Size: 250(H) x 170(W) x 15(D)mm

MB-3593 ***was $44.95***

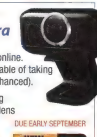
iPhone® not included

$39.95

SAVE $5

High Definition 1080p Web Camera

Enjoy making high-resolution videos for YouTube or chatting online. Features a built-in mic and capable of taking 12MP still images (Software enhanced).



- Full HD 1080p video recording
- High quality 5MP wide angle lens
- Multi-functional clip with 360 degree rotation
- Built-in microphones with automatic noise reduction

QC-3205

DUE EARLY SEPTEMBER

NEW

$39.95

Also available 720p Web Camera NEW QC-3203 $29.95

Wi-Fi Bridge for Smart TVs and Media Centres

Add Wi-Fi capability to your array of home entertainment devices. For those Ethernet only Smart TV's, Game Consoles, Blue Ray Players, this device allows them to connect to your wireless router for internet connectivity.

- Size: 127(W) x 30(H) x 96(D)mm

YN-8361

$59.95

Portable Power Bank

This unit has a huge 5000mAh capacity and outputs up to 2A so it can charge an iPad® with ease. It allows you to charge 2 devices at once. Unit is rechargeable via USB.

- Included: Apple® connector, micro USB, mini USB
- Output voltage: 5V
- Size: 109(L) x 76(W) x 16(H)mm

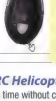
MB-3644 ***was $59.95***

$39.95

SAVE $20

Bluetooth® Keyring Locator with App for iPhone®

An electronic leash that will sound an alarm when your iPhone® leaves your vicinity. You can also use your iPhone® to find the lost keyring.



- Search Range: 20m
- Size: 60(L) x 35(W) x 10(H)mm

XC-0365

$34.95

iPhone® Battery Backup Module

This compact unit provides emergency power for your iPhone 5® and similar products. It is fitted with a Lightning™ connector for your phone and a USB plug for the module to be recharged.

- Size: 73(L) x 69(W) x 10(D)mm

MB-3605

NEW

$34.95

4-in-1 Magnetic Charging Hub

Convenient and attractive mains charger for Smartphone or MP3 player. Features a magnetic connectors for easy connect and disconnect a device.

- Includes 30 pin iPhone® connector, Mini USB, Micro-B USB, Nokia connector
- Mains adaptor included
- Size: 80(Dia.) x 15(H)mm

MB-3651

iPhone® not included

NEW

$49.95

Time Lapse HD Cameras

Create amazing time lapse videos in high definition for all sorts of projects and hobbies. Two models available which are great fun for Dad!

- 2GB memory card/stick included
- PC, media player or suitable TV playback

Weatherproof Time Lapse HD Camera

- Supports USB memory sticks up to 8GB
- 1280 x 1024 resolution
- Size: 192(H) x 93(W) x 60(D)mm

QC-8030

$199.00

Time Lapse HD Video Camera with LCD Viewfinder

- Frame the subject using the LCD viewfinder and 120 degree rotatable lens
- Supports SD card up to 32GB
- 1280 x 720, 640 x 480 resolution
- Power by 4 x AA batteries (included) or via USB (USB cable required)
- Size: 106(H) x 64(W) x 46(D)mm

QC-8034

$229.00

WINNING Choppers for Dad!

A massive range of easy to fly helicopters that Dad will love for Father's Day.

- 3-channel
- Gyroscope for stable flight
- Recommended for ages 14+
- Common spare parts included with all helicopters

Single Blade RC Helicopter with Video Recording

Capture the thrills and spills of your aerial stunts with this highly manoeuvrable chopper.

- 27MHz transmitter
- 1GB microSD card included
- Video capture: 640 x 480 @30fps
- Image capture: 640 x 480 JPG
- Remote requires 4 x AA batteries
- Size: 495(L) x 65(W) x 14(H)mm

GT-3562

$99.00

Double Blade RC Helicopter

Fly up to 2 at the same time without conflict!

- 27MHz transmitter
- Remote requires 4 x AA batteries
- Size: 450(L) x 83(W) x 200(H)mm

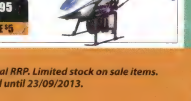
GT-3530 ***was $59.95***

$54.95

SAVE $5

Water Cannon Equipped RC Helicopter

Fly up to 3 at the same time without conflict!



- Shoots a stream of water up to 1m
- IR transmitter
- Remote requires 6 x AA batteries
- Size: 240(L) x 117(H) x 47(W)mm

GT-3496 ***was $49.95***

$44.95

SAVE $5

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/09/2013.

ARDUINO FOR THE WINNING DAD

ARDUINO Modules

USB-Boost Module - Arduino Compatible

Takes a power input of 1.2 to 4.5V, and boosts it to a regulated 5V output up to 500mA. Perfect for powering Arduino projects from batteries, such as a single 3.7V Li-Po cell. Includes status outputs so your microcontroller can actively monitor the status of the power supply.

- USB output jack
- Low-battery warning LED
- Size: 46(W) x 21(H) x 10(D)mm

XC-4239

NEW

$12.95

4 Channel Relay Driver Module for Arduino

Isolates your microcontroller from the relay coils using FETs, includes back-EMF protection, and works with a wide range of relays.

- Individual LED status display on every output channel
- Drive relay coils of 5VDC to 24VDC
- Size: 36(W) x 23(H) x 12(D)mm

XC-4278

8 Channel Relay Driver Shield also available XC-4276 $34.95

$13.95

Humidity & Temperature Sensor Module for Arduino

Measure temperature and relative humidity using a simple interface that requires just three wires to the sensor: GND, power, and data.

- -4°C to +125°C temperature range with +/-0.5°C accuracy
- 0-100% relative humidity with 2-5% accuracy
- 3 to 5V operation
- Size: 31(W) x 23(H) x 4(D)mm

XC-4246

$19.95

ATmega328P MCU with Arduino Uno Bootloader

Comes with the Arduino Uno bootloader pre-installed and features a special label on top which details the pinouts.

- 28-pin DIP format for easy use in breadboards or Arduino compatible boards

ZZ-8726

NEW

$9.95

EtherMega, Mega Sized Arduino Compatible with Ethernet

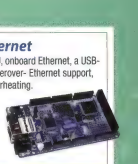
The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Powerover- Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.

- 10/100base-T Ethernet built in
- 16 analogue inputs
- Prototyping area

XC-4256

- 54 digital I/O lines
- microSD memory card slot
- Size: 105(W) x 54(H) x 19(D)mm

$119.00



Also available: ***Mega Prototyping Shield for Arduino to suit*** XC-4257 $17.95

EtherTen, Arduino Compatible with Onboard Ethernet

Includes onboard Ethernet, a mini USB connector, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

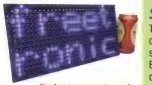
- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built in
- Used as a web server, remote monitoring and control, home automation projects
- 8 analogue inputs
- Size: 76(W) x 54(D) x 19(H)mm

XC-4216

$69.95

Large Dot Matrix LED Display Panel - Blue

A huge dot matrix LED panel to connect to your Freetronics Eleven, EtherTen and more! This large, bright 512 LED matrix panel has on-board controller circuitry designed to make it easy to use straight from your board. Clocks, status displays, graphics readouts and all kinds of impressive display projects are ready to create with this display's features.



Can for size comparison only

- 32 x 16 high brightness Blue LEDs (512 LEDs total) on a 10mm pitch
- 5V operation
- Viewable over 12 metres away
- Tough plastic frame
- Size: 320(W) x 160(H) x 14(D)mm

XC-4251

NEW

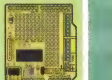
$89.95

Also available: ***Large Dot Matrix LED Display Panel - Red*** XC-4250 $39.95

ARDUINO Shields

H-Bridge Motor Driver Shield for Arduino

Directly drive DC motors using your Arduino compatible board and this shield, which provides PWM (Pulse-Width Modulation) motor output on 2 H-bridge channels to let your board control the speed, direction and power of two motors independently. Perfect for robotics and motor control projects.



- Drives up to 2A per motor channel
- Size: 60(L) x 54(W) x 12(D)mm

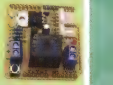
XC-4264

NEW

$29.95

RFID Lock Shield Kit - Arduino Compatible

This shield allows your Arduino to control a door lock using an electric strike plate and one of a number of commonly available RFiD modules.



- Supported readers include ID12, ID20, RDM630, RDM880, and HF MultiTag
- Size: 49(W) x 54(D) x 27(H)mm

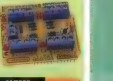
XC-4215

NEW

$29.95

Security Sensor Shield

This shield allows up to 4 security sensors to be connected to an Arduino with full End-Of-Line(EOL) support to detect tampering with the sensors or cable. EOL technology allows the system to detect a variety of events using a single cable pair to the sensor.



- 4 sensor channels
- Supports PIR motion sensors, microwave sensors, glass break detectors etc.
- Status LEDs on each channel
- Size: 60(W) x 54(D) x 17(H)mm

XC-4217

NEW

$27.95

For the Kit Loving Dad

USB Port Voltage Checker Kit

Refer: Silicon Chip Magazine July 2013

An easy way to test a USB port to see if it is dead, faulty or incorrectly wired to help prevent damaging a valuable USB device you plan to connect. Voltage is indicated using three LEDs. Kit supplied with double sided, solder masked and screen-printed PCB with SMDs pre-soldered, clear heat shrink, USB connectors and components for USB 2.0 & 3.0.

$29.95

- PCB: 44 x 17mm

KC-5522

Speed Control Kit for Induction Motors

Refer: Silicon Chip Magazine April/May 2012 + Aug 2013

Control induction motors* up to 1.5kW (2HP) to run machinery at different speeds or controlling a pool pump to save money. Also works with 3-phase motors. Full form kit includes case, PCB, heatsink, cooling fan, hardware and electronics (including revisions from the August Silicon Chip article).

KC-5509

Please note that this is an advanced project for an experienced constructor.

*Does not work for motors with centrifugal switch

$249.00

USB Power Monitor Kit

Refer: Silicon Chip Magazine December 2012

Plug this kit inline with a USB device to display the current that is drawn at any given time. Check the total power draw from an unpowered hub and its attached devices or what impact a USB device has on your laptop battery life. Displays current, voltage or power, is auto-ranging and will read as low as a few microamps and up to over an amp. Kit supplied with double sided, soldermasked and screen-printed PCB with SMD components presoldered, LCD screen, and components.

$59.95

- PCB: 65 x 36mm

KC-5516

Laptop not included

Jaycar Electronics — GIFTS FOR THE WINNING DAD

Better, More Technical

HD Car Event Recorder with LCD

Records the vision through the windscreen as you drive, which can be played back on the colour 2.4" colour LCD to prove what happened in a car accident. Requires SD memory card (available separately) and features HDMI output, JPG snapshot, and 2 bright LEDs to improve night time recording.

- 5MP HD sensor
- Cycled recording
- Video format: H.264/AVI
- Motion detection function
- Supports SDHC cards up to 32GB
- Size: 100(L) x 60(W) x 23(D)mm

QV-3840

$149.00

3MP Mini HD Digital Video Camera

Ultra portable, compact HD video camera and recorder has 2GB of internal memory that will hold up to 50 minutes of video (20 minutes in high definition) or over 3000 photos. Recharges via USB and will gives about 4 hours of use. Pocket clip and desk stand included.

- Supports up to 32GB MicroSD card
- Weighs only 25g
- Size: 23(H) x 78(H) x 14(D)mm

QC-8005

$69.00

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Great Gifts for the Great Dad!

Digital Luggage Scale

Luggage scales that double as a great fishing scale to prove how much your Monster fish weighed!

- 40kg capacity

QM-7232

$19.95

4 Channel IR Helicopter

Fly up to 3 at the same time without conflict!

- IR transmitter
- Gyroscope and 4 motors for stable flight
- 50min charge time gives about 7min flight time
- Remote requires 6 x AA batteries
- Recommended for ages 14+
- Size: 230mm long

GT-3386 *was $39.95*

$34.95 SAVE $5

1:24 Scale Electric RC Truggy

Featuring rear wheel drive, full suspension & front & rear bumpers, this fantastic little unit is made for off-road use.

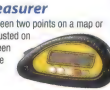
- 27MHz gun style remote
- Average 5-8min drive time
- Remote requires 4 x AA batteries
- Recommended for ages 8+
- Size: 270mm long

GT-3794

$29.95

1:10 Scale Remote Controlled Buggy

Rip up a dirt track straight out of the box. Features digital proportional steering and throttle control for a more life-like driving experience.



- 4 wheel suspension with shock absorbers
- 2.4Ghz gun style remote
- Remote requires 4 x AA batteries
- Recommended for ages 14+
- Size: 485(L) x 300(W) x 150(H)mm

GT-3790

$79.95

Digital Map Measurer

Work out the distance between two points on a map or chart. The scale can be adjusted on each map and the LCD screen has a backlight for night use and an LED flash light.

- Battery included
- Size: 23(L) x 35(H) x 5(W)mm

XC-0374

$9.95

Rechargeable Waterproof Bluetooth® Speaker

A rugged, waterproof Bluetooth® speaker, paired with a Smartphone it allows you to listen to music easily and have phone conversations through the speaker thanks to the built-in microphone. Black shock resistant, rubberised edges and handles make this the perfect companion for outdoor activities. It even floats!

$119.00

- 10 hour playtime
- Size: 230(L) x 102(W) x 67(D)mm

XC-5208

iPhone® not included

For the Music Loving Dad!

AM/FM/SW Rechargeable Radio with MP3

A tri-band compact, portable AM/FM/SW radio with built-in MP3 player and digital clock. Supports USB flash drive and microSD card (32GB max).

- Built-in rechargeable Li-ion battery
- Size: 114(L) x 70(H) x 25(D)mm

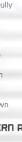
AR-1721

WINNING DEAL! BUY 2 for $50 SAVE $9.90

$29.95

PLL World Band Radio

Receives FM, AM(MW, with 9k or 10k step), SW, LW, AIR bands and uses Phase Locked Loop (PLL) technology to ensure rock-steady, drift free reception. Features sleep function, 500 programmable stations and manual, auto or preset station search.



- Requires 2 x AA batteries
- Size: 120(W) x 75(H) x 30(D)mm

AR-1733

$59.95

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Rockingham (WE HAVE MOVED)	Ph (08) 9592 8000

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details.

Prices valid from 24th August 2013 to 23rd September 2013.

Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

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PIC MICROCONTROLLERS: know it all

Multiple authors **$85.00**

The best of subjects Newnes authors have written over the past few years, combined in a one-stop maxi reference. Covers introduction to PICs and their programming in Assembly, PICBASIC, MBASIC & C. 900+ pages.

PROGRAMMING and CUSTOMIZING THE PICAXE By David Lincoln (2nd Ed, 2011) **$65.00***

A great aid when wrestling with applications for the PICAXE series of microcontrollers, at beginner, intermediate and advanced levels. Every electronics class, school and library should have a copy, along with anyone who works with PICAXEs. 300 pages in paperback.

See Review April 2011

PIC IN PRACTICE

by D W Smith, 2nd Edition - published 2006 **$60.00***

Based on popular short courses on the PIC, for professionals, students and teachers. Can be used at a variety of levels. An ideal introduction to the world of microcontrollers. 255 pages in paperback.

PIC MICROCONTROLLER – your personal introductory course By John Morton 3rd edition 2005. **$60.00***

A unique and practical guide to getting up and running with the PIC. It assumes no knowledge of microcontrollers – ideal introduction for students, teachers, technicians and electronics enthusiasts. Revised 3rd edition focuses entirely on re-programmable flash PICs such as 16F54, 16F84 12F508 and 12F675. 226 pages in paperback.

OP AMPS FOR EVERYONE

By Bruce Carter – 4th Edition 2013 **$83.00***

This is the bible for anyone designing op amp circuits and you don't have to be an engineer to get the most out of it. It is written in simple language but gives lots of in-depth info, bridging the gap between the theoretical and the practical. 281 pages.

PROGRAMMING 32-bit MICROCONTROLLERS IN C By Luci di Jasio (2008) **$79.00***

Subtitled Exploring the PIC32, a Microchip insider tells all on this powerful PIC! Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists. FREE CD-ROM includes source code in C, the Microchip C30 compiler, and MPLAB SIM. 400 pages paperback.

PRACTICAL GUIDE TO SATELLITE TV

By Garry Cratt – Latest (7th) Edition 2008 **$49.00**

Written in Australia, for Australian conditions by one of Australia's foremost satellite TV experts. If there is anything you wanted to know about setting up a satellite TV system, (including what you can't do!) it's sure to be covered in this 176-page paperback book.

NEWNES GUIDE TO TV & VIDEO TECHNOLOGY

By KF Ibrahim 4th Edition (Published 2007) **$49.00**

It's back! Provides a full and comprehensive coverage of video and television technology including HDTV and DVD. Starts with fundamentals so is ideal for students but covers in-depth technologies such as Blu-ray, DLP, Digital TV, etc so is also perfect for engineers. 600+ pages in paperback.

RF CIRCUIT DESIGN

by Chris Bowick, Second Edition, 2008. **$63.00***

The classic RF circuit design book. RF circuit design is now more important that ever in the wireless world. In most of the wireless devices that we use there is an RF component – this book tells how to design and integrate in a very practical fashion. 244 pages in paperback.

PRACTICAL RF HANDBOOK

by Ian Hickman. 4th edition 2007 **$61.00***

A guide to RF design for engineers, technicians, students and enthusiasts. Covers key topics in RF: analog design principles, transmission lines, couplers, transformers, amplifiers, oscillators, modulation, transmitters and receivers, propagation and antennas. 279 pages in paperback.

SELF ON AUDIO

by Douglas Self 2nd Edition 2006 **$69.00***

A collection of 35 classic magazine articles offering a dependable methodology for designing audio power amplifiers to improve performance at every point without significantly increasing cost. Includes compressors/limiters, hybrid bipolar/FET amps, electronic switching and more. 467 pages in paperback.

SMALL SIGNAL AUDIO DESIGN

By Douglas Self – First Edition 2010 **$95.00***

The latest from the Guru of audio. Explains audio concepts in easy-to-understand language with plenty of examples and reasoning. Inspiration for audio designers, superb background for audio enthusiasts and especially where it comes to component peculiarities and limitations. Expensive? Yes. Value for money? YES! Highly recommended. 558 pages in paperback.

AUDIO POWER AMPLIFIER DESIGN HANDBOOK

by Douglas Self – 5th Edition 2009 **$85.00***

'The Bible' on audio power amplifiers. Many revisions and updates to the previous edition and now has an extra three chapters covering Class XD, Power Amp Input Systems and Input Processing and Auxiliary Subsystems. Not cheap and not a book for the beginner but if you want the best reference on Audio Power Amps, you want this one! 463 pages in paperback.

See Review March 2010

DVD PLAYERS AND DRIVES

by K.F. Ibrahim. Published 2003. **$71.00***

A guide to DVD technology and applications, with particular focus on design issues and pitfalls, maintenance and repair. Ideal for engineers, technicians, students of consumer electronics and sales and installation staff. 319 pages in paperback.

See Review Feb 2004

SWITCHING POWER SUPPLIES A-Z

by Sanjaya Maniktala, Published April 2012. **$83.00**

Thoroughly revised! The most comprehensive study available of theoretical and practical aspects of controlling and measuring EMI in switching power supplies.

ELECTRIC MOTORS AND DRIVES

By Austin Hughes & Bill Drury - 4th edition 2013 **$59.00***

This is a very easy to read book with very little mathematics or formulas. It covers the basics of all the main motor types, DC permanent magnet and wound field, AC induction and steppers and gives a very good description of how speed control circuits work with these motors. Soft covers, 444 pages.

AC MACHINES

By Jim Lowe Published 2006 **$66.00***

Applicable to Australian trades-level courses including NE10 AC Machines, NE12 Synchronous Machines and the AC part of NE30 Electric Motor Control and Protection. Covering polyphase induction motors, single-phase motors, synchronous machines and polyphase motor starting. 160 pages in paperback.

PRACTICAL VARIABLE SPEED DRIVES & POWER ELECTRONICS

by Malcolm Barnes. 1st Ed, Feb 2003. **$73.00***

An essential reference for engineers and anyone who wishes to design or use variable speed drives for induction motors. 286 pages in soft cover.

See Review Feb 2003

BUILD YOUR OWN ELECTRIC MOTORCYCLE

by Carl Vogel. Published 2009. **$40.00***

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SERVICEMAN'S LOG

Another day, another dropped phone or tablet

Dave Thompson*

You have to be adaptable to stay in the servicing business. With consumers turning increasingly to smartphones and tablets, often at the expense of traditional PCs, it's been necessary to acquire the specialised skills to take on repair jobs for these devices as well.

IN MY ROLE as a computer serviceman, I get to witness an ever-changing industry. We often make jokes about how the hardware we buy today has already been superseded but in this case, that's not what I'm referring to. Instead, I'm talking about service and support, which must constantly change in parallel with the evolution of the hardware that makes up the IT industry.

For example, the desktop personal computer we have known and loved for the last 30 years no longer reigns supreme, with global sales in their worst-ever slump and almost no hope of recovery. The result is that laptops nowadays easily outsell desktops but even that situation is changing as sales of tablets and smart-phones take over as our most-purchased technology.

That means that any serviceman who relies solely on supporting traditional desktop and laptop computers will eventually go out of business unless he up-skills and reinvents his operations to include these newfangled devices.

This view isn't simply based on doom-and-gloom newspaper stories or articles in technical publications. Over the past 12 months, I've noticed a significant decline in desktop computer repairs, with many clients opting to forgo repairing or rebuilding their broken desktop machines in favour of putting their money into a new machine, usually a "high-spec" laptop or tablet. Of course, the same thing is also happening with laptops, albeit to a lesser extent, with owners often migrating to a tablet when their laptop gives up the ghost.

This is all very well and can be put down to the inexorable march of technology. As a result, I see a time in the not too distant future when hardware manufacturers will phase out desktop specific hardware such as memory modules, motherboards and graphics cards and move instead to producing hardware and peripherals for technology that is selling in bigger numbers such as laptops, tablets or the new micro-factor PCs. These new-fangled desktop-replacement computers, using laptop RAM modules and small-form solid-state hard drives (SSDs), could be designed to mount on the back of a standard monitor using existing VESA mounting points.

Miniaturisation is a natural evolution in all things electronic and will allow us to reclaim some of our desk space. However, these new devices will have hard-wired CPUs, graphics, sound and networking all crammed onto a tiny motherboard and manufacturers can already wring reasonable performance from very small packages. Unfortunately, the introduction of this technology could mean that the days of cheap, ordinary-sized desktop boxes are numbered.

No doubt, the new miniature "average-spec" machines will suffice for many existing desktop computer users but it could mean that the only traditional desktop hardware available in the future will be higher-end components made especially for the gaming and graphics markets. This hardware will likely be far more expensive than it is today and the choices more limited for anyone requiring the sort of grunt found only in full-sized machines.

The fact is, these days more people – even us 'oldies' – are using smart phones to do more than make the odd call or send text messages. Now we are also likely to take photos or video, update our Facebook page, tweet, chat to friends, check our email, find the local pub and even pay for parking and petrol for the car while the home computer sits gathering dust.

And so, when their desktop eventually fails (as they all inevitably do), I've noticed an emerging pattern where owners will opt for either an iPad or an iMac if they already use an iPhone or they'll go for a Windows or Android-based tablet or netbook if they use a smartphone running one those operating systems. Basically, they're aiming

Items Covered This Month

- Repairing smartphone & tablets
- Onix DVD player repair
- Noisy Sony ICF-M350S transistor radio
- A real laptop saga
- DGTEC set-top box repair

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Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

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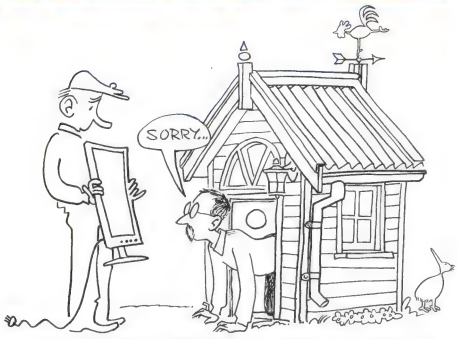


~NOW THAT I'VE RETIRED & DOWNSIZED MY HOME, I NO LONGER HAVE THE SPACE TO WORK ON LARGE SCREEN TVs

The Sony ran on 4.5V and so, just this once, dry finger-tips were pressed into service to mop up the moisture. And while I was wiping the track side of the board, the noise briefly disappeared, to be replaced by clear music.

A little experimentation revealed that the radio would only work with a finger lightly straddling the pins of the LA5003 low drop-out voltage regulator. This regulator supplies power to the chip that handles much of the RF signal path. A quick check of the LA5003's data sheet revealed that a capacitor, referred to as an "RF noise suppressor", is connected between pins 1 & 4 of the device.

Apparently, this regulator is prone to generating RF noise without a suppression capacitor. A 10nF leaded capacitor was duly tacked into place and the radio then behaved flawlessly.

The regulator's existing surface-mount capacitor was subsequently measured and found to be effectively open circuit, though no obvious cause was visible. Resoldering its two ends to the tracks did nothing to fix it either, so the leaded capacitor was permanently soldered in its place and the radio returned to its rightful place above the bench, watching out for stray broadband RF noise emissions.

It's rather ironic that the Sony's only fault after all its years of service as a noise watchdog for other equipment turned out to be an open-circuit suppression capacitor. As a result, it wound up generating its own wideband RF noise. So the ancient art of "hands-on" fault-finding still has a place; but not at high voltages!

A real laptop saga

A. F. of Chinderah, NSW got more than he bargained for when he tried to help a friend out with a faulty laptop. Here's his story . . .

Now that I have retired and downsized my home, I no longer have the space to work on large-screen TVs, such as the 119cm unit that someone recently wanted me to look at. What's more, I reluctantly parted with much of my test equipment, including my scope, some years ago.

These days, I can usually only offer advice to friends and acquaintances who have technical problems. Computer problems are something I can usually deal with though, so when Marvene from our local church asked me to look at her laptop, I decided to give it a go. Hopefully, it would be something simple although I wasn't too sure as to the nature of the problem. All I could find out was that "the thing you click on, is missing".

When I called in to her house, I watched the laptop boot-up without problems. The difficulty that Marvene was experiencing was that the desktop icon that brought up the "Dial-up Dialog Box" had disappeared (yes, she was still using dial-up). All I had to do to fix the problem was find the dial-up program in the Start menu, right click it and drag it onto the desktop to create a new shortcut. It was all too easy.

That wasn't to be the end of it though. Next Wednesday, I saw Marvene again at the op-shop, where we both work as volunteers. A new problem had now emerged with the laptop which was now displaying a "funny message", which went away when she pushed the Enter key.

As I soon discovered, the "Windows Boot Manager" dialog box was now appearing during boot-up, to allow the operating system to be selected. As there was only Windows 7 to be selected, simply hitting the Return key allowed the computer to continue booting.

I was unsure as to why the laptop was now running the Boot Manager but it reminded me of hitting the F2 key to enter the CMOS set-up, or F8 to enter the "Safe Mode" option. So maybe a key on the keyboard had become stuck? I powered down the laptop, stood it up vertically and pressed all the keys several times. The idea was that any dust or debris that might be jamming any keys down would fall out. However, when I restarted the laptop, the Boot Manager still appeared.

Fortunately, the unit was still under warranty, so I phoned the technical assistance number to ask for advice. The technician suggested that I press the F8 key during the restart, which brought up the Diagnostics and Repair Menu. We ran the Repair option without problems and then ran the Diagnostics with no faults reported.

And that was it. The Boot Manager no longer appeared, so problem solved – or so we thought.

Unfortunately, the "fix" wasn't permanent. The next Sunday when we met, Marvene told me that the Boot Manager had reappeared after three days and now the desktop icons were "jumping around" as well. So back I went for a third visit.

Bypassing the Boot Manager was easy and the system appeared stable except that several desktop icons were disappearing and reappearing

not as common. But it does happen and increasing numbers of damaged tablets are now being brought in for repair.

The problem with repairing most tablets is getting them apart. Anyone who has pulled an "i-anything" to bits will tell you how challenging they can be, while the cheaper Android-based tablets are prone to case clip breakage if not handled carefully. Many tablets (and phones) use weird and wonderful screws to hold things together, so it's essential to have one of those multi-tip drivers you can buy from electronics stores. You also need screen suckers and a variety of plastic "prying" tools, although these are widely available and inexpensive these days.

Having the necessary tools doesn't guarantee an easy ride though. Some tablets have hidden screws beneath stickers, blanks, rubber feet and mouldings or in other places you'd never think to look, and this can make disassembly a nightmare.

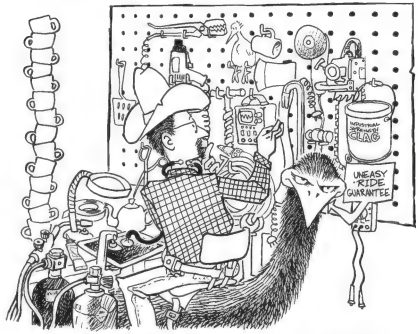
A 10-inch brand-name tablet was dropped off recently with a cracked screen. In this case, the digitiser was intact and so the challenge was to remove it without breaking it. As mentioned, if they are broken, it's relatively simple to remove the bits but not breaking one that's intact is a real test. They do flex alarmingly but are usually very strong and tolerate quite a bit of bending.

That's just as well because the only way to remove this one was by using a blunt plastic pry tool and gently moving along the edges of the digitiser, breaking the tape seal in the process. The screen was also stuck down with lots of tape and I'd hate to try to remove a working screen because I don't think it would be possible without cracking it.

Like phone screens, tablet screens are readily available, though buying them directly from the name-brand's parts department can hurt the wallet so a little shopping around helps. I also stick the screens back down using less tape than the factory, just in case I need to remove them again.

Anyway, having obtained the new screen, I installed it in the machine and stuck the digitiser back down. It flattened out nicely and looked just like a factory job. Best of all, it worked perfectly and the tablet will no doubt give several more years of service.

Phone and tablet repairs give a very different type of job satisfaction and, in my case, now provide a much needed source of income. It's a field that many servicemen likely won't embrace but for me to stay in the game, it's been necessary to develop the extra skills required to service these products.



HAVING THE NECESSARY TOOLS DOESN'T GUARANTEE AN EASY RIDE 'THOUGH...

Noisy Sony ICF-M350S radio

Transistor radios are usually very reliable but they can develop faults that can be difficult to track down. This next story comes from M. H. of Wooloongabba, Qld who tackled a rather puzzling fault in a Sony ICF-M350S. Here's what happened . . .

A Sony ICF-M350S portable radio has been a faithful companion in our power electronics lab for many years. Tuned to local AM stations, the radio not only serves to provide soothing background music but also alerts designers to any wideband RF noise that's occasionally spewed from their wayward creations. Hash in the radio is a good clue that something is amiss and really strong emissions had even been known to precede catastrophic failures.

Unfortunately, over time, our faithful Sony radio itself became increasingly noisy, until it was eventually put aside to be "looked at later". When it was finally brought down from the shelf, the AM band was a total mess of random noise that swamped all but the strongest local stations. The shortwave band was completely unusable but the FM band performed perfectly, which meant that the problem was obviously somewhere in the AM section.

The unit was opened up and initially checked for signs of mechanical damage and any other obvious signs of stress. This gave no clues so all the electrolytic capacitors in this 10-year-old radio were tested in-situ. Each returned a respectable ESR value and was given the all-clear.

Next, we thought that perhaps the faulty part could be detected by freezing but a "can-of-cold" had virtually no effect on the circuit. Heating with a hot air-gun produced no results either and so, with all the easy options exhausted, it was time to get serious.

The local oscillator injection to the mixer was soon located using an oscilloscope and found to be strong and clean, so suspicion now fell on the RF signal path. Then, while I was poking around with the probe, checking supply voltages, the noise suddenly stopped, only to restart again just as quickly. No amount of probing or pressure would then make the noise go away again but at least a likely area on the board had been identified.

The spray freezer was now put to work again but this time concentrated on just the suspect area. A healthy spray produced lots of inevitable condensation but yielded no clues.

Our bench is usually occupied by high-voltage circuitry so any such condensation is always removed using a hot-air gun to avoid nasty zaps.

Serviceman's Log – *continued*

Freebie Onix DVD player repair

It's surprising how often faulty electronic gear can be brought back to life using parts donated by a similar "dead" machine, or even one that's quite different. B. P. of Dundathu, Qld successfully resurrected a DVD player using just this technique . . .

My friend Dave used to run a secondhand computer shop but has since closed his business and moved on to other employment. With the price of new computers coming down so much over the years, people were no longer bothering to buy second-hand computers.

During the course of his business, I used to regularly call in to see him and on one of these visits, he gave me an old Onix DVD player. He said he'd been having a lot of problems with it not opening the tray. Sometimes it would work while at other times it would fail to open unless the button was pressed multiple times or the unit was turned off and on several times.

Eventually, he became sick of its antics and bought a new DVD player. And so that's how I came to inherit the old one. Perhaps I could get it going again and put it to use.

Once I got the unit home, I tested it and found it would usually work after two or three button presses. As a result, I set it up with our system and it was then used periodically. It gave various amounts of trouble in opening the tray, depending on what "mood" it was in, but we tolerated it because it really wasn't a huge hassle.

Then, one day after not being used for some time, it decided that it would no longer open the tray at all, making it totally unusable. And so, with nothing left to lose, I decided to take a look inside to see if I could find out what the problem was.

With the lid off and the unit powered up, I connected my multimeter to the tray motor terminals and checked voltage each time the tray button was pressed. The correct voltage appeared each time the button was pressed but nothing else happened.

That much established, I disconnected the unit from the power and checked the tray motor for continuity. It was open circuit but tapping the motor with the butt end of a screwdriver gave intermittent readings so this confirmed that it need replacing.

I'd previously wrecked a few dead computer CD drives, so I knew that they used a similar tray motor. As a result, I looked through my junk box but couldn't find a motor that was the same as the one in the Onix DVD player.

Fortunately, I also had several dead but still intact CD drives on hand that I hadn't binned, so I started dismantling them. I drew a blank on the first two but dismantling the third turned up a motor that looked to be identical to the DVD player's.

I quickly fitted it to the DVD player, a straightforward job involving just two mounting screws and a couple of wires that have to be soldered to the replacement motor. I then re-assembled the DVD player and tested it.

It then worked reliably so I put the resurrected DVD player back into use. It's still working perfectly two years down the track.

the right one for the phone, something I always do before starting any work so that I don't end up making a mess of things. The biggest challenge with any such repair is getting the old digitiser off the phone. If the whole screen assembly needs to come out, it usually does so without too much hassle but the digitisers in almost every phone I've worked on are stuck down with industrial-strength double-sided tape. This was especially true of the Xperia, which is marketed as a water-resistant phone.

The only way to get the touch-overlay off is to pry open one of the existing cracks and carefully work around towards the edge of the screen, pulling bits of glass out as you go and levering gently against the frame to release the tape. It is a messy and unpleasant task and as it turned out, fruitless in this case.

In most phones, the screen is a relatively thick and hardy piece of kit and as long as you don't twist it about too much or stick something into it while removing the digitiser, everything will be fine. In the Xperia, I discovered that the screen is wafer-thin and after only a few minutes working on removing the digitiser I suddenly noticed a nasty crack had appeared across the width of the screen.

Now I understood why all those vendors sold the two parts as one assembly. Even without my "fists of ham", removing the digitiser without damaging the screen would be an almost impossible task given how incredibly thin it is (though kudos to anyone out there who has actually managed it).

Knowing that I couldn't do any more damage, I soon had the old broken bits and pieces out of the phone. The tape that held it down was then cleaned from the chassis using the tip of a sharp hobby knife and some methylated spirits on a rag.

After ordering a new screen and digitiser assembly (you can buy the digitiser by itself but not the screen), I set everything aside and again waited for parts. I also called the client and told him what had happened and thankfully he was philosophical about it, especially when I said I'd absorb the cost of the extra digitiser (who knows, perhaps I'll get another identical Xperia in at some point which needs a replacement and I'll have better luck next time).

When the new parts arrived, the whole assembly installed quite easily. The only thing I had to do was cut out a new piece of double-sided tape using the frame as a template. It was a little scary sticking it all down because you only get one shot at it.

Fortunately, it worked perfectly and the client was happy. In the meantime, if you know anyone with an Xperia with a cracked digitiser, I have one going cheap!

Servicing tablets

Tablet computers don't get dropped as often as phones and many have fancy armoured rubber or leather cases to protect them, so serious damage is

to unify the operating system across all their devices, something manufacturers are hoping all end-users will ultimately do.

What this means for servicemen like me is that the landscape is rapidly changing. And unless we change with it, service and support as we know it will become obsolete.

Our workshop team used to provide a huge range of support for all manner of computers but that's now changed. Bread and butter work that once kept us in beer and chips can now be mostly done by end-users with zero technical understanding thanks to clever installation routines and ever-evolving operating systems. Once-complicated procedures that in the old days required considerable technical knowledge and skills can now be done quickly and simply by putting in a disk or by using increasingly sophisticated "plug and play" technology. Couple this with the fact that much of the latest hardware is non-repairable and suddenly the computer serviceman often doesn't have a lot to do.

I'm sure repair people in other areas are finding the same thing, with spare parts for devices in their particular field becoming increasingly difficult to source or simply too expensive to buy. As a result, gadgets or appliances that would previously have been repaired or refurbished and given a new lease of life are instead being consigned to the scrap heap.

Increasingly, I am getting clients bringing in printers, scanners, laptops and even tablets and phones that are less than two years old but because of the cost (or lack) of spare parts, these devices end up getting junked long before they should be. A recent example was a large, multi-function laser printer that came in and was just outside its 1-year factory warranty (as usual). The printer part of it had stopped working and when I talked to my brother, who runs a printer repair workshop, he told me that a good number of this particular model fail due to a flexible plastic strap that connects a moving cradle in the printer to the main circuit board.

This strap has dozens of printed copper tracks and is a vital part of the machine yet unbelievably this strap is not available as a spare part. The only hope is to burgle a known working strap from an identical dead unit but, of course, the likelihood is that most such units will have been junked for the same reason.

WE OFTEN MAKE JOKES ABOUT HOW THE HARDWARE WE BUY TODAY HAS ALREADY BEEN SUPERSEDED...

Anyway, after confirming that the strap had indeed split, I considered the possibility of either making another strap from ribbon cable or repairing the existing one. Unfortunately, due to the way it connects to the cradle, neither scheme was feasible and I then had to break the news to my client that the device was non-repairable. They were quite rightly aghast that something so new should have failed in the first place and that because parts were not available, the whole thing was now useless and would either end up being stripped for parts (if donated to someone like us) or finish up in landfill somewhere.

Repairing smartphones

In line with change in consumer preferences, I am now getting more and more clients coming in with phones and tablets. Most are not software related because the operating systems seem to be reasonably bulletproof, probably because you can't really mess with them in the way we messed around with our old desktop machines (unless you're a real hacker). Instead, the vast majority of problems with phones and tablets are impact damage, mostly in the form of cracked or broken screens.

The first thing I check in such cases is whether it is the screen or the digitiser that has cracked. The digitiser overlays the screen and provides the touch functionality smartphones use for navigation. If the screen image looks OK, it is likely just the digitiser that has cracked. If the screen is only half visible, or has coloured lines or artefacts all over it, chances are the screen has cracked as well.

The reason I differentiate is that digitisers can usually be sourced relatively cheaply, with replacements for most models rarely exceeding $50. Screens, on the other hand, are two to three times that amount (or more), so it pays to determine which part needs replacing.

The bad news is that some screens and digitisers come only as a single assembly and that means that the cost is higher again. I recently worked on a Sony Xperia phone that came in with a cracked screen. The phone had been dropped and the shock had shattered the digitiser.

I soon established that the screen itself was sound, so fortunately it only needed the digitiser. The problem was most of the vendors I could find only sold both parts as an assembly and at a high price. After much hunting around, I found an auction-site seller offering just the digitiser and while it was a little more expensive than I would have liked, it really was the best way forward.

I called the client and told him what the options were. It turned out that he had been Googling and was well aware that only whole-screen assemblies were generally available. He was prepared to give a digitiser-only repair a try, so I duly placed an order and put the phone aside to await delivery.

The digitiser arrived a week later and I began by confirming that it was

at random intervals. It was really odd.

The technician requested that I run the diagnostics again several times but no fault was found. I then heard a faint ticking sound coming from inside the laptop, which reminded me of the noise made as hard disk drive heads operate.

I held the phone close to the laptop for the technician to hear and together we decided that the hard disk drive was faulty. So we arranged for a service technician to call at Marvene's house and replace it.

I must say that it was quite enjoyable to watch another person undertake the repair, since it meant that I no longer felt any pressure or responsibility to ensure a successful outcome. Anyway, with the new HDD fitted and Windows 7 reinstalled, it all worked perfectly and everyone was happy.

Until next Wednesday that is, when Marvene said that all the problems had returned. And indeed they had. The technician now decided that the motherboard must be faulty and for good measure, the HDD would again be replaced just to make sure.

This time two technicians arrived at Marvene's and I watched while they spent a long time stripping and re-building the machine. All was well, we thought but again the problems quickly resurfaced.

The following Sunday, Marvene said that she was fed up and had had enough. All the faults were still there and she wanted a new laptop, as it was still within the warranty period. When I phoned the technician, they said they wanted to run the diagnostics again. Marvene's reply was an emphatic "No". She wanted the laptop out of her house and didn't want any more visits from strangers attempting to fix it.

In my now unplanned role as peace negotiator, I passed on the message that the laptop could be sent back to their workshop but at Marvene's expense, under the "Return to Base" clause in the warranty. Marvene agreed to this, on the condition that it would not be returned until it had worked for at least three days in their workshop without problems.

In the end, the laptop was sent to their workshop in Brisbane, where it was promptly repaired and returned. We waited with bated breath – it now behaved normally and several months down the track, is still behaving itself.

So what started out with a simple "I'll take a look at it for you" turned into a frustrating 7-week marathon. What was causing all those mysterious faults? My guess is that it was the keyboard but we never did find out.

DGTEC set-top box repair

Regular contributor B. P. of Dundathu, Qld was recently given a faulty HD set-top box. It didn't take long for him to get it going again . . .

A DGTEC HD set-top box recently came into my possession, its previous owner complaining that it "wouldn't turn on half the time" and was "playing up".

Problems like this are usually caused by a faulty power supply so when I had a few moments to spare, I removed the lid and undid the screws securing the power board. There were a few suspect joints that I re-soldered but I didn't consider them to be bad enough to have caused any problems.

I then took a look at the electrolytic capacitors. At first glance, they all appeared to be all OK but then, on closer inspection, I noticed that the main 220µF 450V electro had a slight bulge at the top. That's a sure sign of trouble, so I removed it and tested it on my ESR meter. The reading was found to be quite high, so I was on the right track.

This capacitor was replaced with one from my parts box, after which I re-assembled the unit and tested it. It now turned on and off faultlessly, so I set it up and re-tuned the channels. We already had an SD set-top box/PVR installed, so this "new" set-top box gave us the extra HD channels we had been missing out on.

This was an easy repair but it would not have been economical to have the unit serviced by a repairer – the cost of the service would have exceeded the cost of a new unit. So it's handy to be able to repair some of the easier-to-find faults like this one.

By the way, faulty electrolytic capacitors are a common problem in devices like older set-top boxes, PVRs, routers and modems. They're usually easy to spot too, a bulge in the can, usually at the top of the capacitor, being a dead give-away. SC

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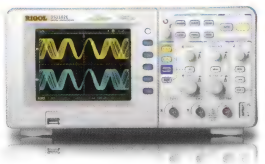

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LifeSaver for Lithium or SLA batteries

by Nicholas Vinen

Rechargeable Lithium-based batteries are great – they have high capacity, long service life, high discharge current, light weight and fast charging.

But they're easy to destroy if you run them down below a particular voltage level and in a lot of applications, all you have to do is leave the device on a bit too long and your expensive battery is lost.

Radio-controlled cars/planes/helicopters generally have a low voltage cut-out feature built in to the motor speed controller but if you use these batteries in other applications, you definitely need this Battery LifeSaver.

As mentioned above, it's also suitable for use with most lead-acid batteries. As with most offices, factories and public buildings, we have quite a few emergency lights/exit signs in our office. While we only have the occasional black-out, we still have to replace several back-up batteries a year which really should have lasted a lot longer except that they were discharged to the point of death. Computer UPS (Uninterruptible Power Supplies) often have the same problem which can make having a black-out quite an expensive event.

The Battery LifeSaver works with 6-24V batteries and can handle currents of up to 20A continuous and 30A peak, making it suitable for use with cordless power tools, emergency lights, small to medium UPS (up to about 300VA) and a wide variety of other devices.

With a quiescent current less than 5µA, it has negligible effect on battery life and as long as the cut-off voltage is set high enough, it won't damage the battery even if left for quite a long time after it has activated – 4.3µA continuous discharge equates to less than 38mAh per year.

Features & specifications

- Works with Sealed Lead-acid, Li-ion, Li-Po and LiFePO4 batteries (6-24V)
- Very low quiescent current, <5µA
- Cut-out voltage adjustable from 5.25 to 25.5V
- High current-handling capability – 20A continuous, 30A peak (charge or discharge)
- 0.3-2V hysteresis, depending on battery type and voltage
- Very small PCB, to fit in tight spaces (34 x 18.5mm)
- Battery can be recharged once cut-out has engaged (maximum 1.5A)

It's very small at just 46 x 18.5 x 5mm assembled and light too (about 5g) so it can be slipped into a tiny space in a battery compartment. It won't cost a lot to build either, which is good since if you have use for one, chances are you will have uses for several.

We certainly do!

Operation and charging

As shown in Fig.1, the unit connects between the battery and load so that it can stop the load drawing any further power once the battery voltage reaches its cut-off value.

It is based on a Mosfet, shown here as a switch. When the Mosfet is off, the load can not draw any further power from the battery. The Mosfet's intrinsic diode is reverse-biased in this condition so no current flows through it either.

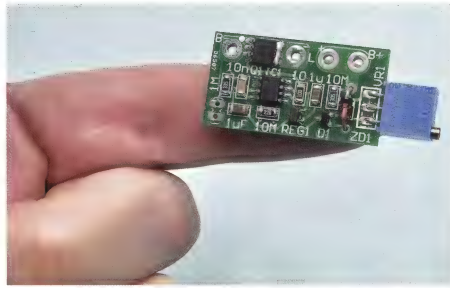
The battery can be recharged either by connecting the charger directly across the battery terminals (if they are accessible) or as shown in Fig.1, by connecting the charger across the load terminals, whether or not the load is still connected. Charge current flows in the opposite direction to discharge current and this path is shown in green.

In many cases, it will be necessary or simply convenient to charge via the load side of the device. In this case, the positive output of the charger is connected directly to the positive terminal of the battery while the negative output is connected via the internal electronic switch and parallel diode.

If the battery voltage is high enough then the switch is on and so charge current can flow through it and charging proceeds as if the charger was connected across the battery.

With the switch off, current can still flow from the charger to the battery but it must pass through the diode. There will be an associated voltage drop and power loss due to the diode junction, heating up the diode (inside the Mosfet). However note that because the battery voltage will appear to be near-zero at the load terminals, some chargers may refuse to deliver current in this situation.

If the cut-out has activated, you should limit the charge current to 1.5A or else the diode could overheat. We tested charging under this condition using a Turnigy Accucell 6 charger and it worked fine as long as we turned the charge current down until the battery voltage had come back up a couple of volts. Once the switch is back on (as confirmed by a healthy voltage reading across the load terminals), you can proceed to charge at the full rate.



Believe it or not, this photo is actually larger than life size, just to show the detail on the tiny (46 x 18.5mm) module. It's cheap to build but could save you a fortune in ruined batteries! Once we attached the input and output leads, we encapsulated it in some transparent heatshrink tube.

If your charger is too "smart" and refuses to supply current with the cut-out activated, it's simply a matter of connecting some sort of current source (or current-limited voltage source) across the load terminals – a plugpack and low-value wire-wound resistor will generally do the trick. It usually doesn't take long to raise the voltage of a flat battery by a volt or two.

Circuit description

The full circuit is shown in Fig.2. We have published similar circuits in the past that used special-purpose ICs but they can be hard to get so this one is based on general-purpose parts: a low quiescent current low-dropout linear regulator (REG1), an ultra-low-power comparator (IC1) and a very low on-resistance Mosfet (Q1).

REG1 has a dual purpose. It limits comparator IC1's supply to 5V which is desirable since IC1 has an absolute maximum rating of 7V. The regulated 5V is also used as a reference for comparison with the battery voltage.

IC1 has rail-to-rail inputs and this means that we can tie its inverting input (pin 2) directly to 5V. In fact, its common mode input range extends 0.2V beyond both supply rails. Pin 3, the non-inverting input, is connected to a resistive voltage divider that is connected across the battery.

The upper leg of this divider consists of a fixed upper resistor (RU) and a trimpot (VR1) while the bottom leg is a single resistor (RL). RU and RL are

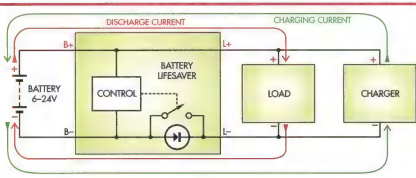


Fig.1: block diagram for the Battery Lifesaver. The unit is connected between the battery and load and disconnects the two (at the negative end) if the battery voltage drops below a threshold. The battery can still be charged in this case, at a limited current, until the voltage rises enough for the cut-out to deactivate at which point full charge current can resume.

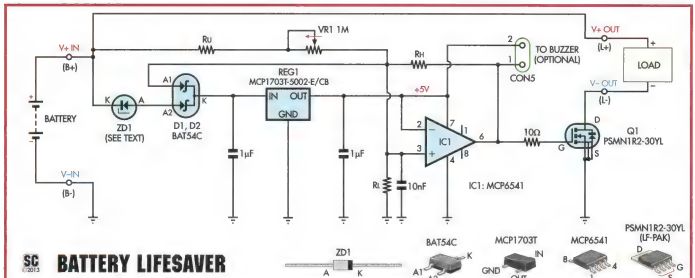


Fig.2: circuit diagram for the Battery LifeSaver. It's based on a low-dropout 5V regulator (REG1), very low power comparator (IC1) and Mosfet Q1, which acts as the switch. Values for resistors RU, RH and RL are chosen to suit a particular battery cut-out voltage threshold and VR1 provides fine adjustment of this voltage. ZD1 is selected to keep the supply voltage to REG1 within its ratings.

chosen so that VR1 can be adjusted to give 5V on pin 3 of IC1 when the battery voltage is at its lower operating limit.

With the battery voltage above this limit, the voltage at pin 3 of IC1 is above that of pin 2 and so the comparator output (pin 6) is high, switching on Mosfet Q1 via a 10Ω resistor. This connects the load to the battery. When on, Q1 not only has a very low on-resistance (about 1.3mΩ) but is fully on with its gate just 4.5V above its source.

If the battery voltage drops too much, the voltage at pin 3 of IC1 goes below that at pin 2, the comparator output goes low and Mosfet Q1 turns off. The only remaining load on the battery is the circuit itself, drawing about 3.2-4.5µA.

Resistor RH, connected between the output and non-inverting input of IC1, gives a small amount of positive feedback which provides 1-2V of hysteresis for the circuit. Its value is selected so that this hysteresis is about 8% of the battery voltage. Without this, as soon as the load is switched off, the battery voltage would rebound and this will cause the load to be switched back on and the circuit would oscillate.

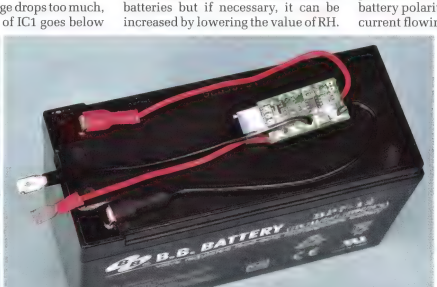
Say the low voltage cut-out threshold is set to 19.8V (for a 24V Li-Po battery). Once the output of IC1 goes high, the switch-on voltage rises to about 21.4V. The battery is unlikely to rebound this much – at least, not right away – so the Mosfet will remain off until the battery is re-charged. This hysteresis should be sufficient for most batteries but if necessary, it can be increased by lowering the value of RH.

The 10nF capacitor across RL filters out noise which may be picked up due to the high impedance of the divider network and smooths battery voltage ripple. It also slows the action of this hysteresis considerably but IC1 has a small amount of built-in hysteresis (about 3.3mV worth) which helps compensate for this.

REG1 has 1µF ceramic input bypass and output filter capacitors for stability, the minimum suggested value for this part. Dual Schottky diode D1/D2 protects the circuit against reverse battery polarity although it won't stop current flowing through Q1's body diode and the load, if connected. The other half of D1/D2 clamps input pin 3 of IC1 to the 5V supply if the battery voltage is particularly high.

Zener diode ZD1 reduces the battery voltage for REG1 and its voltage is selected to suit the type of battery used. REG1's absolute maximum input is 16V. For batteries well below 16V, ZD1 is replaced with a link (see Table 1).

During operation, REG1 consumes about 2µA while IC1 draws just 600nA. The rest of the quiescent current flows through the resis-



When we say tiny, we mean it: here is the LifeSaver sitting on top of a 12V, 7Ah SLA battery and it's not even as high as the spade lugs!

tive divider, hence the resistors used have as high a value as is practical to minimise this current. This is why we have used a combination of resistors and a trimpot to set the cut-off voltage; the highest value of trimpot commonly available is 1MΩ.

Optional buzzer/LED

The PCB has a pair of pads so that a piezo buzzer or LED can be connected to indicate when the battery voltage drops below the cut-off threshold. However fitting this may be not a good idea if you are concerned about the extra current drain on a battery which has been drained to the cut-off voltage.

A buzzer/LED could run the battery flat in a matter of hours so you will need to immediately recharge it once it sounds/lights up.

If you do want to fit a buzzer or LED, it will be driven at 5V by the output of comparator IC1, which can sink a maximum of 30mA. LEDs will require a series current-limiting resistor.

Component selection

Since the battery voltage divider is formed from a combination of fixed resistors and trimpot VR1, we must change the values of these resistors so that the adjustment range of VR1 includes the desired cut-off voltage for your battery.

High value input dividers for comparators pose a problem in that the hysteresis resistor typically must be a much higher value so we are limited by the highest value readily available. Luckily, it's quite easy to get resistors up to about 22MΩ in SMD packages which is higher than the typical maximum of 10MΩ for through-hole parts.

To determine which parts you need, first locate your battery or its closest equivalent in Table 1 and read off the value for ZD1. Next, decide which cut-off voltage you want to use; in very high current drain applications (10A+), especially when using a relatively small battery, you may want to set it a bit lower than specified.

Once you have determined the cut-off voltage to use, find an entry in Table 2 which has a range covering it and then read off the values for resistors RL, RU and RH. These are chosen to give a hysteresis of about 8% of the battery voltage, thus the hysteresis is roughly proportional to the number of cells for a given battery chemistry.

As mentioned earlier, you can adjust the value for RH if necessary – lower values give more hysteresis and higher values less. This will not affect the cut-off voltage although hysteresis does vary slightly as VR1 is adjusted.

Construction

The Battery LifeSaver is built on a PCB coded 11108131, measuring 34 x 18.5mm. Referring to the overlay diagram (Fig.3), start by soldering Mosfet Q1. It has a large pad on the underside

Parts List – Battery LifeSaver

1 double-sided PCB, coded 11108131, 34 x 18.5mm
1 50mm length 25mm-diameter heatshrink tubing
1 length heavy-duty black wire (to suit installation)
1 length heavy-duty red wire (to suit installation)
2 female 6.4mm spade quick connectors (optional; for use with gel cell batteries)
2 male 6.4mm spade quick connectors (optional; for use with gel cell batteries)

Semiconductors
1 MCP6541-E/SN ultra-low-power comparator (IC1) (element14 1439473)
1 MCP1703-5002-E/CB micropower LDO 5V regulator (REG1) (element14 1439519)
1 PSMN1R2-30YL 30V 100A Mosfet (Q1) [SOT-669/LFPAK] (element14 1895403)
1 BAT54C dual Schottky diode (D1) [SOT-23] (element14 1467518)
1 0.4W or 1W zener diode (see Table 1 for voltage) (ZD1)

Capacitors (all SMD 3216/1206)
2 1µF 50V (element14 1857302)
1 10nF 50V (element14 8820155 or similar)

Resistors (SMD 3216/1206)
1 10Ω
plus three resistors, 330kΩ-22MΩ, as per Table 2
1 1MΩ 25-turn vertical trimpot (VR1)

Jaycar Electronics will be releasing a kit for the Battery LifeSaver shortly: Cat No KC-5523 @ $29.95

ST Micro's LFPAK series SMD Mosfets

Mosfet Q1 is an ST Micro part with an incredibly low on-resistance – barely more than 1 milliohm. It is rated to carry 100A but it will dissipate around 1W at 30A ($I^2 \times R$) so without heatsinking (other than the PCB), it won't handle much more than that.

Its on-resistance is so low that losses in the Mosfet itself are a minor component of the dissipation, most of it being in the PCB and wiring. This is only really possible with SMDs since a TO-220 through-hole package has 1mΩ of resistance in the package/leads alone.

By comparison, the LFPAK package (also known as SOT-669) has a resistance of just 0.2mΩ. The semiconductor die is sandwiched between the metal drain pad on the bottom of the device (which also acts as a heat spreader) and a metal plate on top, which also forms the three source leads (pins 1-3). This gives a very large contact area between the device leads and the Mosfet itself, hence the low resistance possible.

The LFPAK has roughly the same footprint as an 8-pin Small Outline Integrated Circuit (SOIC-8), a very common SMD IC package. There is a lot of equipment already designed to handle SOIC parts – pick and place machines, storage schemes, etc – and these can generally work with LFPAK Mosfets with little or no modification.

At a pinch, SOIC-8 Mosfets can be substituted for LFPAK devices and can be soldered to the PCB without needing to modify it. However, losses will be higher in this case. Mosfets in LFPAK use the same pin configuration as typical N-channel Mosfets in SOIC packages.

For more information, see www.nxp.com/documents/leaflet/75016838.pdf

Table 1: battery types, voltages and values for ZD1

Battery type	Nominal	Fully charged	Cut-out (Best life)	(Safe)	(Minimum)	ZD1
Lead-acid	6V	7.2V/7.35V*	5.75V	5.5V	5.25V	link
Lead-acid	12V	14.4V/14.7V*	11.5V	11.0V	10.5V	3.3V
Lead-acid	24V	28.8V/29.4V*	23.0V	22.0V	21.0V	15V
LiFe 2S	6.6V	7.2V	6.2V	6.0V	5.6V	link
Li-ion 2S	7.2V	8.2-8.4V	6.6V	6.0V	5.4V	link
Li-po 2S	7.4V	8.4V	7.2V	6.6V	6.0V	link
LiFe 3S	9.9V	10.8V	9.3V	9.0V	8.4V	link
Li-ion 3S	10.8V	12.3-12.6V	9.9V	9.0V	8.1V	3.3V
Li-po 3S	11.1V	12.6V	10.8V	9.9V	9.0V	3.3V
LiFe 4S	13.2V	14.4V	12.4V	12.0V	11.2V	3.3V
Li-ion 4S	14.4V	16.4-16.8V	13.2V	12.0V	10.8V	3.3V
Li-po 4S	14.8V	16.8V	14.4V	13.2V	12.0V	5.1V
LiFe 5S	16.5V	18.0V	15.5V	15.0V	14.0V	5.1V
Li-ion 5S	18.0V	20.5-21.0V	16.5V	15.0V	13.5V	8.2V
Li-po 5S	18.5V	21.0V	18.0V	16.5V	15.0V	8.2V
LiFe 6S	19.8V	21.6V	18.6V	18.0V	16.8V	8.2V
Li-ion 6S	21.6V	24.6-25.2V	19.8V	18.0V	16.2V	8.2V
Li-po 6S	22.2V	25.2V	21.6V	19.8V	18.0V	10V

Note: 2S/3S/4S/5S/6S refers to the number of cells in series * gel cell or AGM type lead-acid battery

which must be in intimate contact with the large pad on the PCB to ensure both low resistance (so it can handle high currents) and a good thermal bond for proper heat dissipation.

To achieve this, first spread a moderately thin layer of solder paste evenly over the pad and a good dollop of it on the smaller pin 4 pad, at lower left. Position Q1 over its pads and press it down, then apply heat to the small pin 4 pad so as to melt the solder paste until Q1 is held in place. You may find you have to add some solder wire to get a solid joint.

Check that Q1 can't move, then examine its alignment. In particular, ensure that the other three pins are correctly positioned over their pads and the tab is not totally covering the pad to which it is to be soldered; there should be a thin sliver of pad visible although this may be obscured by solder paste.

To adjust the alignment, re-heat the solder on pin 4.

Once you are happy with its position, melt the solder paste along the edge of the large tab by running the tip of the iron along up and down along the exposed section. It may help to add a bit more solder.

You will need to keep the tab heated for several more seconds so that the paste underneath all melts and fills the gaps, forming a solid junction.

Note that this will require a fairly hot iron as there is a large area of copper connected to this pad. Note also that you will need to put the PCB on a heat-resistance surface as the underside will get very hot indeed.

To avoid overheating the Mosfet itself, stop after about ten seconds. You may need to let it partially cool down and then apply heat for another ten seconds or so, to ensure all the solder paste has melted.

When this happens, the volume of flux smoke produced should drop right off. You can then solder the remaining pins one at a time and clean up any bridges between them using solder wick. If necessary, clean up using isopropyl alcohol.

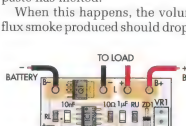


Fig.3: follow this PCB overlay diagram to build the unit. Most parts are SMDs and all mount on the top side of the board. VR1 can be laid over to keep the whole thing relatively thin, so it can be squeezed next to a battery. Heavy-duty wires to the battery and load solder directly to the large pads at top. The pads at lower-left are optionally used to connect a piezo buzzer for a low-voltage alarm.

IC1 is a snack by comparison; it is the same size and has the same pin spacing but there is no big pad underneath so you simply pin it down by one lead, check the alignment and then solder the remaining pins once it is correctly orientated.

For the rest of the SMD components, apply some solder to one of the pads, heat it, slide the part in place using angled tweezers, remove the heat and check the alignment. If it's OK, make the remaining solder joint(s) and then refresh the first one with a dab of extra solder.

Don't get REG1 and D1 mixed up as they look very similar; the resistors will be labelled with their value (although you may need a magnifying glass to read it) but the capacitors won't be.

If you do get confused, you should be able to tell which is the 10nF as it will be thinner than the other two.

With the SMD components in place, fit ZD1 with the orientation shown and then VR1, with its adjustment screw towards the bottom of the board. You can bend its leads over before solder-

ing, as we have, to keep the overall assembly thin so that it will fit into tight spaces.

Note that if you are going to use the unit with a sealed lead-acid battery ("gel cell"), these are often fitted with spade lugs.

So you could solder wires to the PCB and crimp female spade lugs onto those connected to the B+/B- terminals and male spade lugs to those connected to the L+/L- terminals. That would then allow you to easily connect the device in-line between the battery and device without any additional soldering.

Testing and adjustment

The easiest way to set up the Battery LifeSaver is using a variable voltage power supply (eg, a bench supply) but if you don't have one, you can instead connect a fully charged battery (or power supply with a similar voltage) across a 1-10kΩ potentiometer.

The pot wiper connects to the B+ terminal on the PCB while the negative terminal of the power supply goes to B-.

We used small hook probes to make the connection to these terminals, to avoid having to solder them initially (see photo) but if you do solder wires on, it's probably a good idea to keep them long and use thick, heavy-duty wire so that you can also use them for the final wiring.

Adjust the bench supply or pot to give the board close to the nominal battery voltage (measured across B+ and B-), then measure the current flow by connecting a multimeter, set to mA or µA, in series with one of the board's supply leads.

You should get a reading of around 5µA. If it's more than 10µA or less than 2uA then something is wrong and you will need to carefully check the assembly (note that not all multimeters can read such low currents with precision).

Set the DMM to volts mode and measure between the + terminal of CON5 (upper) and the B- battery terminal. Assuming your DMM is accurately calibrated, you should get a reading in the range of 4.95-5.05V.

Now adjust VR1 fully anti-clockwise (until it clicks) and measure the resistance between the L- and B- terminals. The reading should be close to 0Ω, meaning Q1 is on. If not, check the supply voltage and try turning it up slightly but don't exceed the full-charge voltage of your battery.

Assuming Q1 is on, reduce the supply voltage to the PCB until it is at your desired battery cut-off voltage, as measuring between B+ and B-.

Confirm that Q1 is still switched on, then slowly turn VR1 clockwise until Q1 switches off and the resistance reading increases dramatically. It should be above 10MΩ and may give a reading of "oL" (ie, effectively open circuit) on your DMM.

To check this, we simply clipped the test leads connected to L- and B- onto our DMM probe tips and the used clip leads to connect the power supply to B+ and B-. This allowed us to vary the voltage while watching the Mosfet's resistance.

You can confirm that the board is working properly by turning the supply voltage up by the hysteresis voltage (a couple of volts should do); Q1 should then turn back on again.

Table 2: resistor values for different cut-out voltage ranges

Cut-out range	Hysteresis	RL (1%)	RU (1%)	RH	Iq*
5.2-5.6V	~0.3V	10MΩ	330kΩ	10MΩ	3.2µA
5.6-5.9V	~0.4V	10MΩ	1.0MΩ	15MΩ	3.2µA
5.8-6.4V	~0.5V	6.8MΩ	1.0MΩ	15MΩ	3.7µA
6.4-7.4V	~0.5V	3.9MΩ	1.0MΩ	15MΩ	4.4µA
7.4-8.7V	~0.6V	3.3MΩ	1.5MΩ	15MΩ	3.5µA
8.4-9.7V	~0.6V	3.3MΩ	2.2MΩ	22MΩ	3.8µA
9.6-11.0V	~0.8V	3.3MΩ	3.0MΩ	22MΩ	4.4µA
11.0-12.3V	~1.0V	3.3MΩ	3.9MΩ	22MΩ	4.3µA
12.2-13.6V	~1.1V	3.3MΩ	4.7MΩ	22MΩ	4.3µA
13.6-15.1V	~1.2V	3.0MΩ	5.1MΩ	22MΩ	4.6µA
15.5-17.1V	~1.4V	2.7MΩ	5.6MΩ	22MΩ	4.7µA
16.2-17.9V	~1.6V	3.0MΩ	6.8MΩ	22MΩ	4.6µA
17.7-19.3V	~1.6V	2.7MΩ	6.8MΩ	22MΩ	4.5µA
19.3-21.1V	~1.6V	2.4MΩ	6.8MΩ	22MΩ	4.6µA
20.6-22.6V	~1.6V	2.2MΩ	6.8MΩ	22MΩ	4.9µA
22.2-24.2V	~1.8V	2.2MΩ	7.5MΩ	22MΩ	4.9µA
23.7-25.8V	~2.0V	2.2MΩ	8.2MΩ	22MΩ	4.9µA

* Approximate quiescent current at cut-off voltage

Installation

Once you have soldered the leads to the PCB, it's a good idea to sleeve the whole thing with 25mm diameter heatshrink tubing so that once it's inside the battery compartment, or secured to the outside of a battery, it can't short against battery terminals or any other exposed metal.

Wire it up according to Fig.3. There are two different ways to connect the load's positive terminal. Ideally, it should go straight to the battery's positive terminal but since that will already be wired to the Battery LifeSaver board, in may be easier to connect it to the L+ terminal on the PCB instead.

This means the full load current has to pass through the PCB twice which will slightly increase losses but should not cause any problems within the ratings we have provided. SC

Simple 12V/24V Regulator for 70V Solar Panels

Design by Branko Justic*

Want to run 12V lights and accessories independently of any 230VAC mains supply? With a 72W solar panel, this simple regulator and a 12V lead-acid battery, you can run a long string of LED lights and have light in a remote location or in the city – when others are struggling with candles!

Over the last few years there has been a growing interest in running 12V lights and accessories using a solar panel, a 12V battery and not much else. Normally this involves using a 12V solar panel and battery and often an MPPT (Maximum Power Point Tracking) regulator to ensure that the maximum output of the solar panel is available.

The reason for this is that the maximum output from a 12V solar panel is actually delivered at about 17V and this does not match up well when directly charging a battery.

In this article we look at quite a different approach whereby a 72W panel with a maximum output of 90V is fed to a step-down regulator to charge a 12V or 24V battery.

This achieves much the same result as an MPPT regulator working from a 12V solar panel but the 72W panel is quite cheap and has the distinct advantage of also being able to produce a 24V DC output, if required.

However, we think most people would probably want to use a 12V output since more LED lights are available at this voltage.

By the way, there is no reason why this solar panel and regulator could not be used to charge the batteries in a car, caravan or boat, or even provide 12V power in a remote cabin or when camped in a remote location. It will charge a 12V battery at a useful 5A.

The 72V Cadmium Telluride thin film solar panel measures 1200 x 600mm and is quite heavy at about 15kg since it is essentially a large piece of glass.

By contrast, the step-down regulator is on a small PCB measuring 145 x 58mm.

The circuit

The circuit is shown in Fig.1 and is based on an SG3525A switchmode regulator (IC1) driving two IRFB4020 Mosfets. Each Mosfet drives one half of the primary winding of step-down transformer T1. The gates of the Mosfets are alternately driven by IC1 and so each half of the primary winding is fed with the full voltage of the solar panel which can be as high as 90V in full midday sunlight. IC1 runs at about 100kHz, as set by the 1.5nF capacitor and 6.8kΩ resistor connected to pins 5, 6 and 7 of IC1.

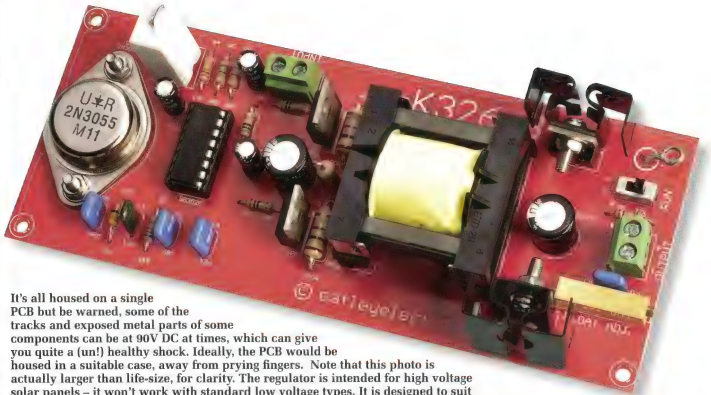
The AC output voltage from the transformer is rectified by two SR1060 Schottky barrier dual diodes, with each diode pair paralleled to reduce their forward voltage.

The effective turns ratio of the transformer can set by links to provide a nominal 12V or 24V DC output to a battery.

Either way, you need to set the output voltage using multi-turn trimpot VR1. For a 12V battery, the float voltage setting is 13.8V and for 24V it is 27.6V. VR1 and the 27kΩ resistor connected to the DC output form a voltage divider which feeds a portion of the output back to pin 1 of IC1.

This is compared to 5.1V connected from pin 16 to pin 2, part of an internal comparator. When the feedback volt-

WARNING
ELECTRIC SHOCK HAZARD
This panel has an open circuit voltage of 90V DC: There is a SHOCK HAZARD at the panel terminals and on parts of the PCB.



It's all housed on a single PCB but be warned, some of the tracks and exposed metal parts of some components can be at 90V DC at times, which can give you quite a (un!) healthy shock. Ideally, the PCB would be housed in a suitable case, away from prying fingers. Note that this photo is actually larger than life-size, for clarity. The regulator is intended for high voltage solar panels – it won't work with standard low voltage types. It is designed to suit Oatley Electronics' 1200 x 600mm CdTe Solar Panel, which puts out around 72W in bright sunlight at about 70-90V. In fact, Oatley Electronics have a special offer for this kit plus the solar panel for $119 (cat K330p) – see www.oatleyelectronics.com

* Oatley Electronics

age to pin 1 exceeds 5.1V, IC1 reduces the duty cycle of the drive signals to the gates of the Mosfets so that the output voltage is maintained within tight limits.

Note that the circuit shows the 27kΩ resistor connected to the output via slide switch S1 when it is in the RUN setting which is the normal mode. It should not be run in SET mode.

SET mode has been included to enable the output voltage of the circuit to be set when the solar panel is not generating much voltage, ie, when it is indoors or maybe it is dark or raining.

In this case, the above-mentioned 27kΩ voltage divider resistor is not connected to the DC output of the circuit but to the 5.1V reference (ie, pin 16 of IC1). The voltage at test point TP is then set by trimpot VR1 to 1.885V, to obtain 13.8V (to suit a 12V battery) when the circuit is in RUN mode.

Similarly, to set the output to suit a 24V battery, VR1 is adjusted to obtain 0.94V. To repeat, the circuit must not be run in SET mode when it is connected to the solar panel and a battery as the output will be unregulated.

Now while the full DC voltage of the solar panel is fed directly to the drains of the two Mosfets, that voltage is far too high to be fed directly to IC1 since it has an absolute maximum voltage of only 35V. Its supply needs to be drastically reduced which is the reason for inclusion of the ancient-looking 2N3055 power transistor, Q1.

Why use this antediluvian device? It is not included for its power rating but it does have a high voltage rating for this mode of connection – 95V – so it can cope with the solar panel's full output. It also offers good heatsinking – without an external heatsink.

In fact, Q1 functions as a simple series regulator with a 10V zener diode connected to its base, bypassed by a 100µF capacitor. By emitter-follower action, it feeds 9.3V to IC1 – well within its DC ratings. Having said that, the 1.2kΩ 5W resistor connected to the collector of Q1 reduces its dissipation so that no heatsink is required.

Finally, notice that there is a 47µF 100V electrolytic capacitor connected to the input supply from the solar panel but it is isolated by a series 4.7Ω 1W resistor, to reduce the output impedance of the panel supply.

It was found that if no 4.7Ω resistor was incorporated into the circuit, it had the potential to blow the fuse on a multimeter if it was used to check the short-circuit current of the panel. Furthermore, in isolated cases it also

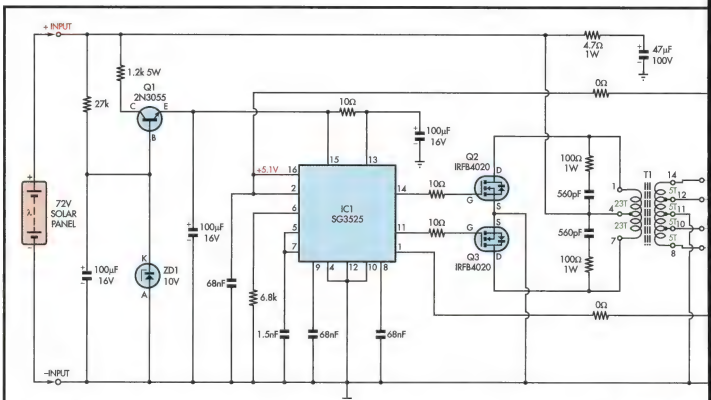
PARTS LIST – Solar Panel Regulator

1 PCB, code K326-3, 145 x 58mm
2 ferrite core halves
1 prewound transformer bobbin
2 transformer clips
1 SPST slide switch, PCB mounting
2 2-way screw terminal blocks, PCB mounting
1 DIL 16-pin IC socket
4 M3 10mm screws, nuts and washers
2 TO220 heatsinks

Semiconductors
1 2N3055 power transistor
2 IRFB4020 Mosfets
1 SG3525 SMPS IC
2 SR1060 dual Schottky diodes
1 10V 400mW Zener diode

Capacitors
3 100µF 16V electrolytic
2 47µF 100V electrolytic
4 68nF monolithic ceramic
1 1.5nF metallised polyester
2 560pF 200V disc ceramic

Resistors (0.25W 5%)
2 27kΩ 1 6.8kΩ 2 100Ω 1W
3 10Ω 1 4.7Ω 1W 2 0Ω
1 1.2kΩ 5W
1 20kΩ 10-turn potentiometer



SC 2013 72V SOLAR PANEL BATTERY CHARGER / REGULATOR

Fig.1 is the complete circuit diagram. It suits a high voltage (~72V) solar panel, also available from Oatley Electronics. It will not work with the more common low voltage panels.

led to failure of one of the Mosfets.

Construction

All components mount on the top side of the PCB so construction is relatively simple.

Start by checking the PCB for any defects and if all is OK, commence construction by soldering in the resistors.

Use the resistor colour code table at right and/or check the values with a digital multimeter before you place them – it's too easy to make a mistake!

Note that there are two 0Ω resistors to be placed – these are on the top left of the PCB. The lone 5W resistor (1.2kΩ) must be mounted standing vertical off the PCB.

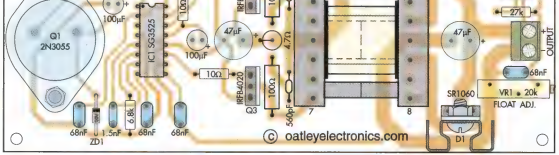
Next to go in are the low-profile capacitors, followed by the electrolytic capacitors. The marking for two electrolytics might confuse you: on the PCB screen overlay, they're labelled as 22-100µF. In the kit, they're almost certainly 47µF 100V.

Now it's time to place the various semiconductors. Be careful not to confuse the Mosfets and Schottky diodes – they do look the same but are clearly identifiable – nor get them around the wrong way (see the circuit diagram and component overlay).

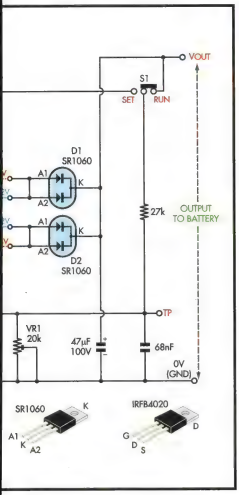
The Schottky diodes have heatsinks fitted but these can be left until last as they will get in the way.

The IC must be inserted in the right

Fig.2 shows the component placement on the PCB. All components as such mount on the top side of the board, as shown here, but you will need to place two links on the underside of the board (as shown in Fig.3 opposite) to set up your charger to suit a 12V or 24V system.



(TOP VIEW)



Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	27kΩ red violet orange brown	red violet black red brown
❑	1	6.8kΩ blue grey red brown	blue grey black brown brown
❑	2	100Ω brown black brown brown	brown black black black brown
❑	3	10Ω brown black black brown	brown black black gold brown
❑	1	4.7Ω yellow violet gold brown	yellow violet black silver brown
❑	2	0Ω single black stripe	single black stripe

way around too – identify the notch at one end which goes towards the top.

The collector of Q1 connects to the copper track underneath by means of a nut and bolt. Ensure there is good connection between the pad and the screw head – it might pay you to place a layer of solder on the pad first.

After soldering in the switch (S1), the two terminal blocks and the trimpot (VR1), all that is left is the transformer.

This is supplied as a pre-wound coil on a bobbin, two ferrite cores and two clips to hold it all together. It's vital that the primary side, which has only three connections, goes to the left-hand side looking at the board as shown below. Both sides have seven pins to solder to the board; the primary has three of these connected while the secondary has five.

Pin 1 on the transformer is clearly identified – ensure it goes into the top left PCB hole. Finally, fit the heatsinks to the two Schottky diodes using 3mm nuts and bolts. A smear of heatsink compound on the metal of the diodes wouldn't go astray.

Links

That almost completes assembly. All you have to do now is solder two links on the bottom (copper side) of the PCB which determine whether you have a 12V or 24V system.

It's quite easy to "bridge" between the appropriate pads with solder – just be sure you get the right pads!

If you have any problem with solder not taking, use an offcut from a resistor or capacitor to make the small wire links.

Setup

After checking your component placement, you need to set up the charger. This can be done with a solar panel connected or not.

If you have a solar panel connected and it's producing power (ie, it's sunny!), disconnect the battery being charged and switch S1 to the "run" position. Measuring V_{OUT} with a DMM, adjust VR1 to give 13.8V for a nominal 12V system and 27.6V for 24V. Leave S1 in the "run" position.

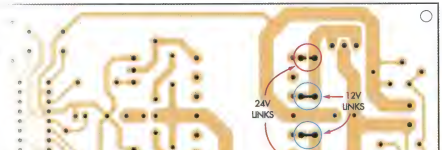
If you don't have a solar panel connected or if it isn't producing power (eg, it's dark!) you could simulate one by connecting, say, a 50V DC supply in series with a 50Ω resistor.

Alternatively, without any input (solar panel or simulated), leave the battery in position and switch S1 to the "set" position. Connect your DMM to the test point (TP) and adjust VR1 so that it reads 1.885V (for 12V) or 0.94V (for 24V). Don't forget to switch back to "run" when finished.

Cabling

All cabling should be run in a gauge not only heavy enough for the current but also with insulation more than capable of handling the ~90V which this panel can produce during bright sunlight.

It's more likely that your panel will produce less than this – say 70-80V – unless it is tracking the sun, is kept scrupulously clean and is never shaded by trees or even posts. SC



(BOTTOM VIEW)

Where d'ya geddit?

This kit is available exclusively from Oatley Electronics who hold the copyright on the design and PCB.

A Solar Panel Regulator Kit and a FS272 CdTe High Voltage Solar Panel (as discussed in this article) are available for the special price of $119 plus freight, which varies according to your location (the panel is quite heavy!).

Email branko@oatleyelectronics.com.au for a freight quotation.

You can order online – www.oatleyelectronics.com – or by phone from Oatley Electronics during business hours (9am-4.30pm Mon-Fri) on (02) 9586 3564

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Issue: Sept 2011

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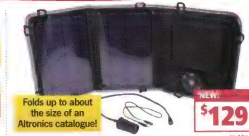

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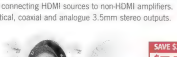

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$749 NEW MODEL!

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K 5182 Optional speaker protector	$19.95

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(SC September '12) The new colour maxi-mite is here! Upgraded with colour VGA output, stereo audio synthesiser, real-time clock, Arduino compatible connector and 20 more I/O lines. A powerful programmable computer for innumerable logging, monitoring and switching projects. Note: SD card not included.

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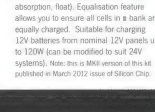

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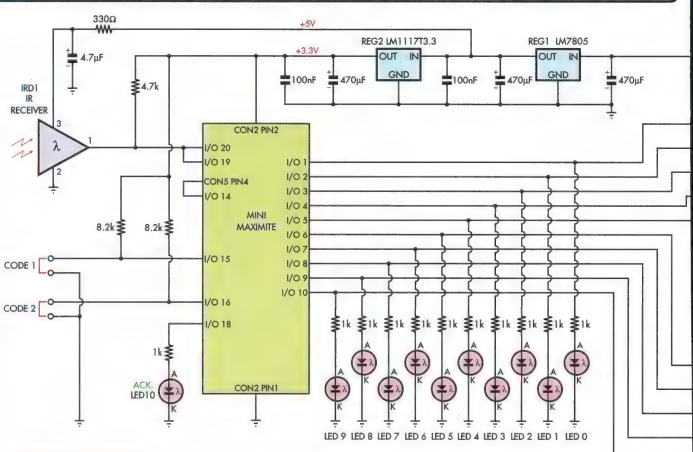
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



CODE 1/CODE 2 JUMPER TABLE		
CODE 1	CODE 2	DEVICE
OUT	OUT	TV
IN	OUT	SAT 1
OUT	IN	SAT 2
IN	IN	CD

MiniMaximite version of the 10-channel remote control receiver

This circuit is an implementation of the 10-Channel Remote Control Receiver described in the June 2013 issue of SILICON CHIP. It mirrors the original design as closely as possible, the main differences being the controller chip and the corresponding software. Consequently, all the operating and set-up procedures are exactly as described in the original article, with the one exception being that there is no provision for incorporating a UHF module.

On receipt of an IR signal from a remote control using the Philips RC5 protocol, the first task of the MiniMaximite is to decode the signal. The RC5 code contains 14 bits of information. There are two start bits followed by a toggle bit. Then come five address bits and finally six command bits.

Each bit has a duration of 1.778ms, giving a total time for the 14-bit frame of 24.892ms. The whole frame is then repeated after 114ms. Midway

within each bit, a "1" is represented by a low-to-high transition and a "0" is represented by a high-to-low transition.

The toggle bit (0 or 1) changes every time a key is pressed but remains unchanged while a key is held down. This information is used to control whether the action repeats in this case.

The five address bits constitute the device code. A remote using TV mode sends a device code of zero whereas in SAT1, SAT2 and CD modes the device code sent would be 8, 10 & 20 respectively. These are the devices coded for using the Code1 and Code2 jumpers connected to pins 15 & 16 of the MiniMaximite. Finally, the six command bits contain the code for the key pressed.

The circuit diagram shows the output of the IR receiver connected to pins 19 & 20 of the MiniMaximite. One of these pins is defined as an interrupt for low-to-high transitions while the other is defined as an interrupt for high-to-low transitions. In this way, the MiniMaximite can distinguish between a "1" or "0". It's not quite as simple as it appears because the nature of the signal means that not every transition represents a digit.

To assist in the decoding, the MiniMaximite needs a source of clock signals that can be counted. The period of the clock signal needs to be much less than half the period for one bit, ie, much less than 889µs. There are no suitable commands in MMBasic to do this but it is possible to use the SOUND 200000 command to generate clock signals with a period of 5µs.

The circuit diagram shows the SOUND output connected to pin 14, which is defined as a counting input. Each transition in the signal generates an interrupt which records the instantaneous count of 5µs pulses. From that information the time between transitions can be calculated and it is from these times that the signal can be decoded.

Note that the time interval between frames (114 ms) is very large when compared to the time between pulses (1.778ms) so, by using this large gap, it is possible to record and distinguish between many successive frames. This program records 90 transitions which is sufficient to cover more than the first three frames. It then looks for the 114 ms gaps between frames 1 & 2, 2 & 3 and 3 & 4.

The program then decodes frames 2 & 3 and compares the address and command content of each frame. These should be identical but if they are not there has been some error in the signal path and the ACK LED will flash 10 times. If there is agreement the program continues on to process the requested operation.

Setting up momentary and toggle operation is exactly as described in the June 2013 article. The nature of the outputs and their initial states is stored in the file *a:data* on the MiniMaximite.

Power is provided from a 12V DC plugpack. The 7805 regulator provides the 5V supply for the IR receiver and this supply is further regulated by an LM1117T3.3 to provide 3.3V for the MiniMaximite. The current rating of the plugpack will depend on what's connected to the outputs (eg, relays, motors, lights etc) and the nature of the outputs (toggle or momentary). This is also covered in the original article.

Jack Holliday,
Nathan, Qld. ($60)

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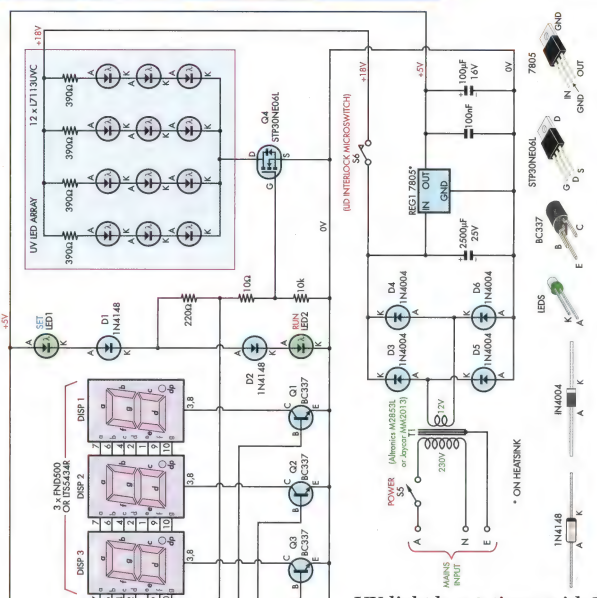


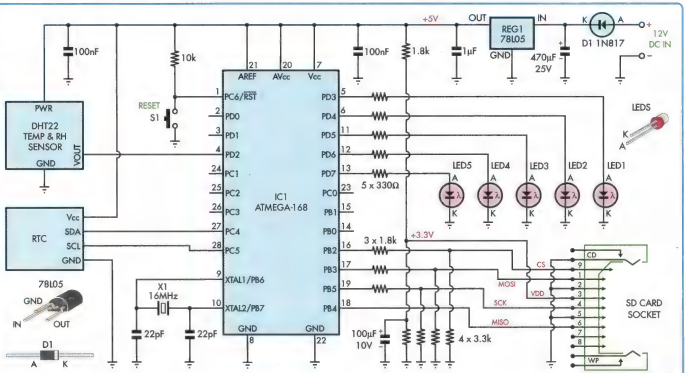
UV light box & timer with LED array

This UV light box timer is based on a PICAXE20M2 microprocessor with an array of UV LEDs to expose the photo-sensitive board. The 3 x 4 array of UV LEDs, spaced on 25mm centres and placed 70mm below the exposure glass plate, will illuminate a board up to 75 x 100mm. These dimensions give an exposure time around five minutes. You may install extra UV LED arrays for larger board sizes but cost becomes an issue. The Kingbright L7113UVC from RS Components cost $5 per LED.

IC1 operates as a "down counter" with push buttons S2-S4 entering the exposure time in seconds on the 3-digit 7-segment LED display (eg, enter 300 seconds for a 5-minute exposure time). The program uses the "time" command to keep accurate time. Press the run pushbutton (S1) to start counting down.

The display is multiplexed using transistors Q1-Q3 while seven 100Ω current-limiting resistors drive the anode pins. Each time you enter a new exposure time it is saved in EEPROM and will become the default exposure time for future cycles and is not lost if the power is switched off.

Two green LEDs are provided to define both "set" mode



Arduino temperature & humidity data logger

This Arduino-compatible data logger comprises a DHT22 temperature/humidity sensor, Real Time Clock Module, an ATmega 168 microprocessor, an SD memory card holder, five status LEDs and supporting circuitry. Every 30 minutes the data logger will record the time and date, temperature in °C and the humidity and store it in the SD memory card.

The SD card has a voltage divider to change the signal voltage from 3.3V to 5V so that the Atmega 168 can successfully read/write to it and a voltage divider has been used to the derive the 3.3V rail for the card from the 5V supply from REG1. (Editor's note: high speed SD cards may need a higher current supply rail and so a 3.3V regulator may be necessary).

The five status LEDs are connected to port D and are as follows: LED1 = SD card error; LED2 = DHT error; LED3 = SD write; LED4 = RTC error; and LED5 = SD card status.

Any errors that occur, such as disconnected pins, will cause the corresponding error LED to light up. On start-up, the SD card status LED will flash five times, followed by either a steady light or error LEDs lighting up. When the minute on the real time clock is either at "00" or "30", it will write the current data to the SD card. This is indicated by the "SD write" LED briefly flashing.

The file in which the data will be written to by default is named "datalog.txt". This can be changed by renaming it in line 136 of the programming code. The data can be read by any computer supporting an SD card slot and a simple (or complex) text editor. The program is written in the "Arduino IDE" or "C" and uses 20,632 bytes (Temperature and Humidity Data Logger V1.3.ino). It can be downloaded from http://www.siliconchip.com.au/Shop/6

Jed Hodson,
Galong, NSW.

Jed Hodson is this month's winner of a $150 gift voucher from Kare & Forbes

(LED1) and "run" mode (LED2), showing when you can set the exposure time or alternately when the counter is running. The pushbutton inputs (pins 3-6) use the "pullup" command to enable internal pull-up resistors. For reliable operation, use pushbuttons fitted with "snap action" mechanisms.

After each exposure cycle is completed the 3-digit display blanks out while a short tune plays on the piezo speaker. The previously saved exposure time is then displayed.

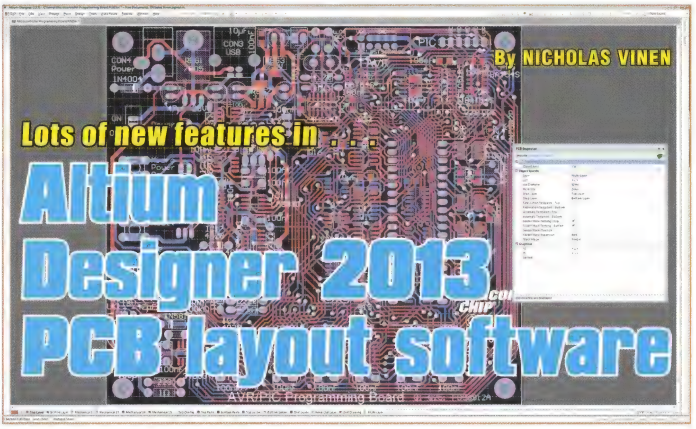
The LED array consists of four identical rows containing three UV LEDs, each with a 390Ω current limiting resistor and all driven by Mosfet Q4. The array requires an 18V DC supply to ensure that it is higher than the combined forward voltage drop across the UV LEDs (3.4V per device) and the series resistor.

The power supply produces a 5V DC regulated rail for the PICAXE micro and 18V DC unregulated for the UV LED array. S5 turns the whole unit on or off while interlock switch S6 turns the UV LED array off when the lid is open. This is important because looking directly at the UV LEDs could harm your eyes.

The prototype is a simple wooden box divided in two compartments. One compartment is used as the light box and has the UV LED array mounted on the bottom while a glass plate is mounted under a hinged lid. The other compartment holds the electronics with the timer section and power supply, while the user controls and 7-segment displays are mounted on the compartment lid.

The microprocessor is programmed using the ICSP header and a PICAXE special serial or USB cable to load the "uvbox_20m2.bas" program. The software is available from www.siliconchip.com.au/Shop/6

Ian Robertson,
Engadine, NSW. ($60)



Altium Designer is the successor to the popular Autotrax and Protel ECAD (Electronic Computer-Aided Design) programs but it has a lot more features and capabilities than its predecessors. We take a look at the latest version and detail some of its best features for circuit design and PCB layout.

IN THE NOVEMBER 2010 issue of SILICON CHIP, we reviewed Altium Designer Summer '09, along with the NanoBoard 3000 hardware. At the time, we had had about a month to try out Altium Designer but hadn't done a lot of serious work with it.

Since then, the software has gone through a number of revisions and we have used it extensively for PCB layout. While it has a lot more capabilities than just PCB layout – including circuit simulation and microcontroller/FPGA programming – we tend to mostly use it for drawing up circuits and subsequently laying out PCBs to implement them.

We recently decided to take another look at Altium Designer, for two reasons. Firstly, because a number of new features and improvements have been made in the last three years and secondly, because we now have more experience with Altium and this has given us further insight into its particular strengths and weaknesses.

To recap briefly, for those who are unfamiliar with Altium, it is a high-end piece of electronics design software which runs exclusively on Windows computers and is used by many businesses and individuals to design products ranging from a single component on a small board up to monsters with thousands of components and many layers. It is the successor to Protel and inherits much of its predecessor's design philosophy while adding a lot more.

New features

While there have been many updates to Altium Designer since we originally looked at it, AD13 is the first major update in a few years. It is installed as a new piece of software, rather than just updating the previous version and it introduces a number of new features. But upon investigation, we realised that most of the improvements since AD09 have been introduced incrementally over the intervening time and these in total have resulted in an overall substantial improvement in Altium Designer.

One feature missing from Altium Designer that has finally been added in the latest update is layer transparency (see Fig.1). You can now set the transparency for any visible layer as a percentage, allowing layers beneath to be seen through it rather than obscured by it.

This has a couple of important benefits. Firstly, when doing tricky routing jobs, it's helpful to be able to see all the layers at once so that you can figure out whether a complex route (possibly involving multiple vias and tracks on many different layers) will work or whether there are too many obstacles in the way. Previously, this

required flipping between these layers to make each in turn the top-most, so you could see them in their entirety.

The transparency also allows you to better see just how multiple track segments in a single layer overlap. This can be important since Altium can automatically move and re-route tracks but only as long as they are continuous and it's quite easy to get into a situation where two tracks appear to be joined but there is a small gap or overlap in the middle so they are considered separate. With transparent tracks, it's easier to find such situations and fix them.

Fig.1: close-up of a mixed through-hole/surface mount PCB design with the new layer transparency feature enabled. Tracks on all layers can be seen, through pads or tracks on the currently selected layer.

Active Bill of Materials

This feature has just been introduced with AD version 13.3 and ties in with the existing Vault and Bill of Materials systems, which were already quite powerful. Basically, what it lets you do is shop for components for your design from within Altium and then associate a given component in your design to the model and get supplier information such as price and stock as well as specifications, images, etc (see Fig.2).

This can be used to fill in data on the schematic, generate a total cost for the project and ultimately produce a list of parts to order.

The latest update also improves the very useful PDF export feature, which we'll explain briefly below.

Other useful features

Over the years of using Altium Designer, we've found some things that it is particularly good at doing. In many cases, these features are not available with other ECAD (Electronics Computer Aided Design) packages. Here is a list of those we consider most useful, in no particular order (we won't go into much detail on basic tasks such as placing components – those are things that just about any ECAD package can do and haven't changed much since our last review):

- The ability to push tracks and vias, during and after track routing: this has come in very handy on a number of occasions. Compare Figs.1 & 3. All we did to change the PCB was click on the lower via to the left of Q28 (labelled "PIN10") and drag it up and to the right. If there's room, Altium will then re-route tracks around it and even push some aside (eg, the blue track labelled "PIN2") but only as much as

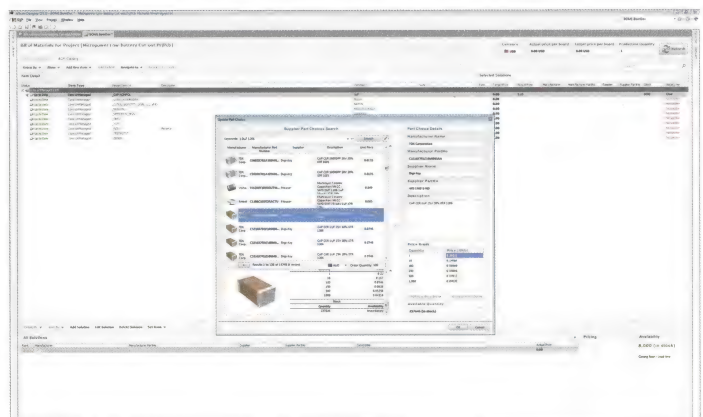


Fig.2: Active Bill of Materials links your design to part suppliers, giving access to real-time data on pricing and stock. This data can then be used to generate an overall price for manufacturing the design, as well as making sure that all the parts you need are available in sufficient quantities.

Fig.3: the same PCB as shown in Fig.1 but here we have dragged the "PIN10" via up and to the right. Note how nearby tracks have been automatically moved to make room for it. Doing this manually can be time-consuming on a large, complex design.

necessary. We cleaned up the result a bit to remove unnecessary wiggles in the track but that was only a few seconds of extra work.

You can do something similar with tracks too; simply select one and then drag it and it will move adjacent tracks as it is dragged, if necessary. You can even re-order tracks like this in some cases, eg, when the other track emerges from a via and the track you are dragging can go around either side.

Of course, you could do this all manually but it would be quite a lot of work; PCB layout is an iterative process for all but the simplest designs and when using other ECAD packages, we've spent hours ripping up and re-laying tracks before we found the best routing solution. With Altium, this same job can take minutes if you take advantage of its ability to push and re-route tracks for you.

Altium can also potentially move tracks while you are placing a new one, as long as you are using the "HugNPush" mode. In this mode, as you move the mouse alongside another track, it will place the new one at a safe distance (ie, adhering to your minimum clearance rules) but if you try to move the new track through a gap that is too small, Altium will move tracks that are in the way (if possible) to make room.

- Searching for items on the PCB based on their characteristics and doing mass changes. Again, this is a real time-saver in some situations compared to other packages which require you to manually and laboriously change every single one.

For example, let's say you design a PCB to be manufactured in a particular factory then you move production to another factory which has a larger minimum via size. Your design may have hundreds or even thousands of vias. With Altium you can right-click on one, select "Find Similar Objects" and you are then presented with a dialog which allows you to choose which criteria to select – object type, layer, hole size and so on.

Upon clicking "OK", all matching objects are selected. You can then use the PCB Inspector (see Fig.4) to alter their properties en masse. In this case, you would simply type a new value into the "Hole Size" input box and press Enter and the hole size of all selected vias would change to the new value. You could also change the via pad size at the same time, if necessary. Any clearance violations which result from this are then highlighted and you can then fix them by, say, moving the vias (Fig.5).

This same process can be used to change text label fonts, line widths, pad shapes – all manner of object properties.

- TrueType fonts on PCBs: this is a simple feature (to use, anyway) but can make your PCBs look a lot more classy. We still tend to use the default vector font for component values and so on as it keeps file sizes small and it's relatively easy to read. TrueType fonts are great for labelling the board with its product name, company logo and so on, for a really professional presentation.
- 3D view: not as pointless a feature as it may at first seem. You need to use components with 3D models (or make your own) but once you do, all

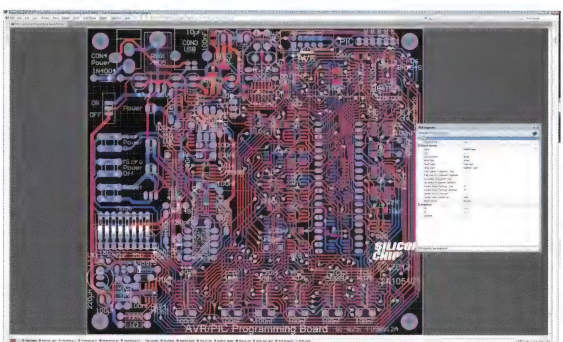


Fig.4: a "zoomed-out" view of the same PCB as shown in the earlier figures with all vias selected, using the "Find Similar Objects" dialog. The properties of the objects can then all be changed at once using the PCB Inspector dialog, shown here. In this case, we can change the via drill size, copper diameter, tenting (whether or not they are covered with solder mask), net membership and other properties.

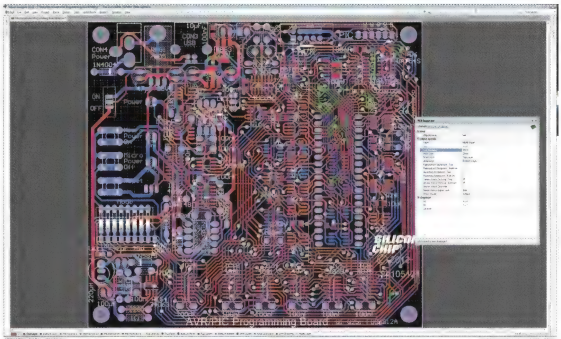


Fig.5: after increasing the hole size and diameter for all vias, some are now too close to adjacent tracks or pads so these have been highlighted in green. This is the "online design rule check" feature in operation. You can also get a list of violations and zoom in to see each one in detail. Each individual violation can be fixed by moving one or more of the components which are too close together, as set by your chosen design rules.

you need to render your board in 3D is a single key press. This can be used to check component fit, especially for those which have an overhang. It can also be used to make sure that the board and its components will fit in a specific case, with the shafts and LEDs lining up with the appropriate holes and so on.

It's also a great tool to show clients what a design will look like before it has actually been built. Compare the 3D rendering of our CLASSiC DAC board (Fig.6) to the adjacent photo we published from a similar angle. It's a pretty good match. Note that we built all the 3D models ourselves, as we are using a custom library. These are all built from vertical extrusions, cylinders and spheres. More advanced 3D models are possible if you have access to 3D "STEP" models (Standard for the Exchange of Product model data).

- Complex design rules: design rules (minimum clearance, minimum track width, minimum hole size, etc) can depend on object attributes such as net membership. For example, say you are laying out a PCB with high-voltage and low-voltage sections. You need different track clearance rules depending on whether the two tracks in proximity are low-voltage, high-voltage or one of each.

In many PCB layout programs, you have to check this manually, eg, set the track clearance to the minimum for the low-voltage section and then check each high-voltage track in turn to ensure it is far enough away from any low-voltage tracks. But in Altium you can set up multiple rules so that this happens automatically and you will be alerted if any given pair of tracks are too close for safety.

For those who aren't familiar with the terminology, we should point out that a "net" is a collection of component pins and tracks which are electrically connected. An Altium schematic drawing can be used to automatically generate a list of nets ("netlist") and this is brought into the PCB layout, both to act as a guide during layout and in order to perform the Design Rule Check (DRC) which alerts you to short circuits between nets, nets which

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Fig.6: a 3D view of our CLASSiC DAC design, using simple 3D models we built ourself using the 3D tools Altium provides. These are vertical shape extrusions, cylinders and spheres. As you can see, despite the simplicity of this approach, the result looks quite realistic and can be used both to visualise the design and to check the mechanical fit of components and overall assemblies before a prototype is built.

are too close to each other (clearance violations) and so on.

We used net-specific clearance rules to help lay out the Soft Starter for Power Tools PCB (published in July 2012). Once the net classes and design rules are defined, you can lay tracks in the low voltage section and they will automatically stay away from the high-voltage tracks.

Fig.7 shows an extra track added to this design, between the low-voltage section at right and the incoming mains Active track at left. Note that it is flagged as violating the clearance rules with the Active track even though it is further away from this than it is from the low-voltage ground track at right.

In fact, Altium has a very powerful design rule system which allows you to set up many different custom rules depending on requirements, eg, some areas of the PCB can have different track clearance or width rules and so on. Design rules are assigned an order of priority so that you can set up exceptions to rules and you can even have rules which are based on boolean expressions. It's a powerful system.

- Ability to "tent" individual pads/vias, change individual hole sizes, pad sizes, shapes and component outlines: normally, you define component characteristics in your PCB library and them simply place them on a board. But there are many times when a component on the PCB must vary from the default. For example, you may need to make the pads of a particular component thinner to make enough room for a track to pass through the middle while in other cases, you want them to remain larger to minimise the chance of tracks being lifted during soldering.

With some PCB layout programs, in this situation you are forced to create a new library element with a different pad arrangement and you quickly end up with many variations of each component to suit different situations – it's messy. With Altium, you can simply edit the component on the PCB by "unlocking" it and then making changes. You can re-lock it when you are finished.

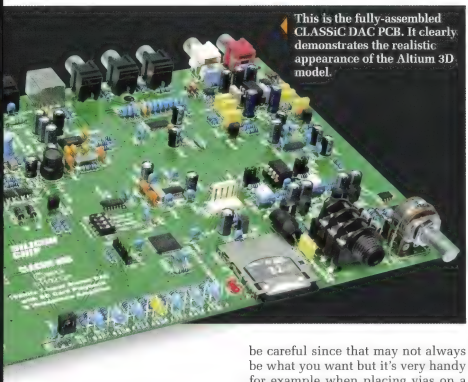
This isn't without its drawbacks – for example, if you later change the base component in the library and then update the PCB with this new configuration, any changes to components which have been varied are lost and must be re-applied. So this is a feature to be used with caution but it can still be a real time-saver.

We also like the fact that we can selectively "tent" vias and pads on either or both sides of the PCB, so that they are covered with solder mask during the manufacturing process. Some layout programs force you to do all-or-nothing tenting and by making this part of the manufacturing export step, you can easily forget to do it, eg, when re-ordering a board you have had made previously.

- Interactive routing: while other PCB layout packages have interactive routing, Altium's version works particularly well. We described the most useful modes, "Walkaround" and "HugNPush", in our last review.

One useful feature we didn't mention is the ability to press the backspace key while laying a multi-segment track to go back a step if the last segment didn't get placed quite where you wanted it to. It's also quite easy to move track segments after laying them without having to re-do the connecting segments.

Also, because Altium picks up the initial track size from the pad/track which you click on to start placing, you



This is the fully-assembled CLASSiC DAC PCB. It clearly demonstrates the realistic appearance of the Altium 3D model.

don't have to constantly go changing the current track size while doing a layout with a variety of different track widths, eg, 10 thou/0.25mm wide for signals and 40 thou/1mm for power. This may seem like a small point but it saves a lot of fiddling and frustration.

Also, when a new component or via is placed, if it is in contact with an existing track, it is automatically added to the same net. You have to be careful since that may not always be what you want but it's very handy for example when placing vias on a ground or power plane – although there is also an automatic via stitching feature which can do this for you.

- Polygon pours: while this is a common feature of PCB layout programs, Altium's handling of it works particularly well. For a start, after placing a polygon, you can easily move its corners and edges, add vertices and so on. It's also easy to re-pour a polygon (around tracks, pads and other polygons) and to "shelve" it, which

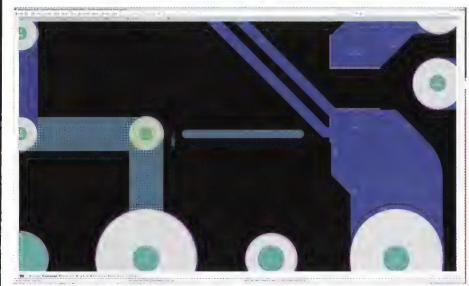


Fig.7: Altium's powerful Design Rule Checking system has several benefits for PCB design and layout. This demonstration shows how tracks assigned to nets in various "net classes" can have different clearance rules. The track at left carries 230VAC mains voltage (≥100 thou clearance) while the track at right is low voltage (≥20 thou clearance) and hence the added track in the middle causes a rule violation for one but not the other.

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How Multi-Layer PCBs Are Designed & Made

IN THIS ARTICLE, we have referred to "tented vias" and "polygon pours" but readers may not be familiar with these terms. Making double-sided and multi-layer PCBs is quite complex so we won't give the full details here but the following information should go some way towards explaining these terms.

As with a single-sided PCB, double-sided PCBs are generally made using a sheet of fibreglass as a substrate but with copper foil laminated on both sides and then etched. The problem is how to connect the tracks on the top of the board to those on the bottom. The simplest method is to drill a hole through both and then solder a wire or component lead on both sides. But this is virtually impossible for components that sit right on the PCB surface and soldering feed-through wires is expensive and time-consuming.

Vias

Vias are used to perform the same function. To create a via, a hole must still be drilled but it can be quite small; they are typically around 20 thou or 0.5mm in diameter although larger/multiple vias are used for high-current tracks. Copper is then plated onto the cylindrical fibreglass surface of the hole, forming a hollow wire which joins the two tracks.

In fact, a modern double-sided board will have all or most of the holes plated, including those for component leads. This means that component leads are held into their mounting holes more strongly than they would be if they were just soldered to the copper tracks, even if soldered on both sides. It's also easier to just plate all the holes although exceptions can be made if necessary.

Most modern PCBs also have a "solder mask" layer applied as one of the final steps. This is a polymer film which covers the copper tracks but leaves the pads exposed, making accidental track-to-track, track-to-pad or pad-to-pad bridges much less likely when soldering. It also greatly reduces the amount of solder required when using wave soldering and helps improve the reliability of reflow soldering.

Since the holes drilled in a PCB aren't necessarily perfectly aligned with the tracks, vias require a certain amount of copper around them on both sides to make sure the hole is touching copper and thus the through-plating makes the required connection. But it isn't necessary to solder anything to these vias and often they are placed under components, making it impossible.

So it's common to have the solder mask completely cover a via. This is known as "tenting". Through-hole pads may also be tented on one side of the board, which we find helps with soldering (less solder wicking through).

Multi-layer boards

Sometimes, having just two layers isn't enough; vias take up space on the board and at some point a design becomes so complex that the number of vias required to lay it out with just the two layers becomes excessive. ICs in packages with very closely spaced pins or lands (ie, those in BGA or LGA packages) generally require at least four layers to "break out" all the connections from the IC to tracks leading away from it.

Multi-layer boards are fabricated as multiple thin double-sided boards which are then laminated together. Clearly, alignment in this process is very important. Additional steps are required to allow vias to pass through multiple layers.

The simplest form of via on a multi-layer board is one which goes all the way from the top layer to the bottom layer, joining all the layers between. However it is also possible to have a "blind via", which starts at either the top or bottom layer but terminates at some intermediate layer, leaving the remaining copper layers above or below it electrically isolated. Similarly, it is possible to have "buried vias" which are only between two or more internal layers and not visible from the outside at all, once the PCB has been completed.

Altium has comprehensive support for multi-layer boards and allows each via to have a unique profile, connecting to some or all of the layers with different-sized pads on each layer if necessary.

Polygon pours & thermal reliefs

The copper tracks used to join components are usually formed from line segments; curves are also possible and for radio-frequency signals may be required. But sometimes you need to join many pads and vias together and the easiest way is to do a "flood fill", where all the otherwise unoccupied areas on a particular layer are filled with a continuous island of copper and this island is then connected to each point as required.

temporarily removes it from the design as this makes it easier to edit tracks which intersect with it.

You can define the polygon pour order which is important for deterministic results when polygons overlap. You can also determine whether copper is poured directly into contact with pads or if they are instead connected with (thermal) "reliefs" which are basically short sections of track. This is important to avoid dry joints for components connected to large copper planes which can otherwise act as a heatsink during soldering.

The polygon-pad connection style can be defined on a per-PCB or per-polygon basis, which is useful because for high-power tracks you may need the direct connection whereas components connected to a signal ground plane can do so via reliefs. You also get several options for each polygon pour, for example, whether to remove "dead" copper, ie, copper islands with no actual electrical connection.

- Net & layer highlighting: when you move a mouse over a track or pad in Altium, the connected net is automatically highlighted. But more importantly, you can hold down Control and click a net and the rest will dim. These two effects can be used in combination to see where various tracks cross over on different layers and so on. A feature we find even more useful – even vital in some cases – is the ability to view and edit a single layer of a PCB at one time which is accessed via the Shift + S keyboard shortcut. This is a great way to remove the clutter from the display when working on a complex layout and it's also incredibly useful when you are trying to select a group of tracks but not the components or other objects that connect to them.

One could get a similar effect by manually disabling all but one layer and then re-enabling them later but that would be a lot of work. With this shortcut, you can easily flip between

This is a common way to make ground connections but can also be used for power distribution on multi-layer boards. On a four-layer board, it may be the case that one layer is used for ground (bottom, say), one for power (top) and two for signal routing. This means that wherever ground or power is required – and for some designs, that may be at hundreds of different points – you just need to place a via at that point from the appropriate power plane layer.

Any through-hole pads must be on the top or bottom layer, to allow components to be soldered to it after the PCB has been made, so in this case you need a "hole" in the power or ground plane so it isn't shorted to one of those. Most PCB layout programs therefore provide an automated polygon pour feature.

You specify a layer and an outline (which may be the whole PCB or a section of the PCB) and assign it to a particular net. Within that outline, all blank spaces (or depending on settings, contiguous blank spaces) are filled with copper, with an appropriate clearance to all adjacent tracks and pads. Tracks or pads within this area that are assigned to the same net are joined to or merged with this copper fill.

Fig.9 on the following page shows a portion of the CLASSiC DAC PCB which has ground planes on both the top and bottom layers formed by "polygon pours". As you can see, it is automatically poured around the vias that are under IC5. Also note the "via stitching" joining the two ground layers for a low impedance at upper left.

Thermal reliefs

The vias between the top and bottom ground planes in Fig.9 use the "direct connect" style where a hole is simply drilled through the two planes and plated though, giving the lowest possible resistance for the connection.

However, the pads joining to this ground plane (ie, the pin of each component that's connected to ground) are joined using "thermal reliefs". This is true for both through-hole and SMD components. For example, look at the two capacitors to the left of IC5. The left-most pad of each is isolated from the ground plane by a narrow ring where the copper has been etched away, except in four places, 90° apart.

The idea here is that the electrical resistance of the connection is still very low because although the sections joining the pad to the ground plane may be narrow, they are also very short. This usefully raises the thermal resistance between the pad and ground plane. The ground plane, being a large sheet of copper foil, has a fairly low thermal resistance to the ambient air surrounding the board.

As a result, trying to solder any components directly to the ground plane is going to be more difficult as it will draw heat away from the joint. Molten solder applied to the PCB that is hot enough to solder a component joined to a thin track (eg, during wave soldering) may solidify on a ground-connected pad before a proper joint has been formed. But the relief-connected pads have an intermediate thermal resistance to ambient, ie, lower than other pads but not much lower and so only a small amount of extra heat is required when soldering.

The thermal reliefs may seem too small to make a noticeable difference but if you try soldering to pads with both connection styles you will find that the difference is quite significant. And when using automated assembly techniques, relief connections may be required to get consistent results.

top and bottom layers (or on a multi-layer board, inner layers) to follow what is going on.

- Layer sets: a quick and easy way of showing or hiding groups of layers at once. For example, you can have a minimal layer set (top and bottom copper plus pads, say) and a more complete layer set for when you need to see everything (including mechanical layers) and quickly switch to the minimal layer set while doing routing.
- PDF export: this is a great way to show schematics to co-workers or create documentation for clients. Larger designs will normally take up multiple schematic sheets and these can be exported in a single action to a multi-page PDF. With the latest version of Altium, you can even click on components in the PDF schematic to see the component attributes (type, voltage, power rating, tolerance etc).

You can also export the PCB to a PDF but this is less useful for a variety of reasons, including low contrast with red/blue on white (for some reason it's much easier to see on black). We prefer exporting PCBs to Gerber files, which can also be sent off for manufacture.

Advanced features

Altium also has a number of features which we do use but rarely. Many of these are important for designing commercial equipment, especially high-speed digital circuits. For example, when laying out boards with fast memory (eg, DDR) or high-speed buses, you want to keep each track in the bus to much the same length, so that the signals arrive at the other end simultaneously.

Altium provides a few ways of doing this which really make it easy. In a recent design, we used the Interactive Length Tuning feature to lengthen individual tracks in a bus until they were all the same (Fig.8). With this tool, all you do is set up the parameters and "wipe over" a track and zig-zags are automatically added until its length has increased to the set maximum.

A similar effect can be achieved using the "Equalise Net Lengths" menu option. There's also an option for tuning differential pairs, which are normally routed together but may need to be modified to have the same length, depending on the details of the route. Once you've finished routing tracks, you can then use the Signal Integrity checker (also visible in Fig.9) to check that all the tracks meet your various requirements for overshoot, undershoot and so on.

Potential improvements

With such a large piece of software, it's inevitable that there would be some things we don't like. And while there are a few, generally they are more minor annoyances than serious problems. Probably the most obvious limitation is that you need to keep your computer hardware up to date to get decent performance.

Having said that, fast computers are really quite cheap these days and the hardware cost is a pretty insignificant cost of running the software – the license itself being far more expensive. Altium's disk footprint has been somewhat reduced by recent updates, from multiple gigabytes down to about 1GB if you are mainly doing PCB layout work, which shows that they have a desire to optimise the software rather than just adding more "bloat".

We do occasionally run into bugs but generally these do not result in any lost work – Altium has a pretty good system for automatically handling "exceptions" gracefully. But on occasion, it can go into an endless loop and it has to be terminated. Normally though, this only happens when using

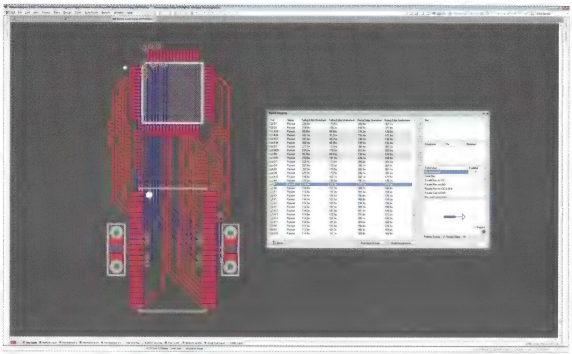


Fig.8: Altium has a number of advanced design features for modern, high-speed digital/analog PCB designs. Here we are showing two – Interactive Length Tuning (to add the "wiggles" to the tracks in the bus at left) and the Signal Integrity dialog which performs analysis of the design to ensure it meets design specifications.

one of the newer features; the basic PCB layout portion of the software itself is quite reliable.

We have also run into some fussiness importing and exporting certain types of file, such as old Protel PCB files and Gerber files. PCB files generally import correctly except that sometimes text is misplaced or rotated. PCB files are sometimes not exported correctly though – for example, if you export a PCB with a polygon fill to a format that doesn't support polygons, they are silently dropped from the design. We should probably consider ourselves lucky that Altium still supports such an ancient file format at all – in a similar situation, many other vendors would forget it entirely.

As for Gerber files, the format is notoriously poorly standardised so it isn't surprising that we have to fiddle with the file headers to get Altium to successfully import a file produced in another ECAD package. With a modified header, it processes the file correctly.

Some areas of the user interface which we previously would have criticised have been improved with updates over the last few months. It's somewhat unusual when a software company brings out frequent updates to their product and they actually make it noticeably better! For example, certain menus which appear during PCB editing now pop up more quickly, resulting in a smoother work flow.

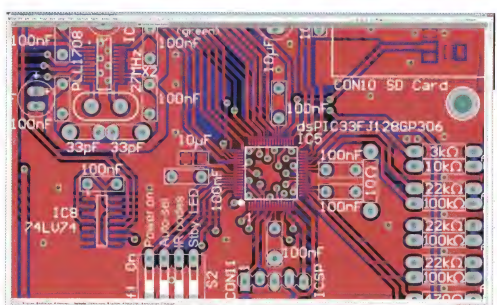


Fig.9: close-up of a PCB design (the CLASSiC DAC) showing copper ground planes on both top and bottom layers made using polygon pours. Note how the "poured" copper "flows" around vias, tracks and any other areas of copper that belong to different nets. Component pads joined to the ground plane are via "thermal reliefs" while vias are joined directly to both planes.

Conclusion

Altium Designer is a very powerful tool for PCB layout, especially for demanding designs. That comes at a price though: $A7245 + GST initially and $A1750 + GST per year for updates after the first year. That's not an unreasonable amount to pay for such a powerful tool if it's used every day in a commercial environment but it's certainly out of the reach of amateurs; there is a (much cheaper) student version though.

We would certainly recommend Altium as a circuit and PCB design and layout tool, if you can afford it. It has so many useful features that users will need to attend some of their training seminars before they will have a chance to use its full potential.

For further information, contact Altium on +61 2 9410 1005 or email sales.au@altium.com SC

By Ian Batty

Best Of British: the Bush TR82C Mk.2 transistor radio

A classic 7-transistor set from the early 1960s

Bush Radio began in 1932, becoming part of the Rank empire in 1945. Along with the iconic DAC90 and DAC10 valve radios, they also produced the distinctive TV22 TV set. Here we take a look at their distinctive TR82C Mk.2 7-transistor radio.

IF THE BUSH TR82C's classic styling evokes the era of rock'n'roll, it's with good reason. But it's not exactly unique, the styling having been based on an earlier valve portable designated the MB60.

Released in 1957 and designed by the brilliant David Ogle, the MB60 just screamed "modernity". It set a benchmark for style which was well-matched by its performance and sound quality.

Background to the TR82C

With the 1950s transistor revolution well under way, Bush responded in 1959 with the TR82. Initially kitted out with alloy-junction OC44/45 germanium transistors in the front end, it was a solid performer. By contrast, the TR82C Mk.2 described here used alloy-diffused AF117 transistors in the front end.

A Mullard design brief in 1960 for a 6-transistor set with three alloy-diffused transistors described it as offering "outstanding performance". So was Bush TR82C based on this circuit? A quick check in my Mullard "Reference Manual of Transistor Circuits" revealed that the Bush set is almost identical to Mullard's design.

In addition, having previously given Raytheon's T-2500 (also a 7-transistor set) a thorough going-over, I was curious to see what differences there were between it and the TR82C.

Face-off: T2500 vs TR82C

Whereas Raytheon used a craftsman-built timber cabinet, Bush settled for an elegant moulded cabinet with clean, bold lines. A large dial dominates the front, with its anodised red scale set back in a well behind the tuning wheel. As a result, unlike the Raytheon's "fiddly" dial, the TR82C is easily tuned using either a single finger or a thumb and fingertip spanning across the dial wheel. In addition, the TR82C uses a slow-motion dial for ease of tuning (as does the T2500).

The volume, wave-change and on/off-tone controls all sit in a well at the top of the case. The volume and on/off-tone control knobs are well-knurled and easy to operate, while the MED(ium) and LONG waveband switches are easy to access and respond positively. Ergonomically, this is one of the best sets in my collection.

By contrast with other sets, the cabinet uses a variety of trims. The metal parts are chrome-plated and the plastics are either in their original colours or "flashed" with bright finishes. The control legends are recess-moulded and filled with dark paint, making them highly wear resistant. In my set though, the dial wheel has yellowed and grazed with age. This badly dims

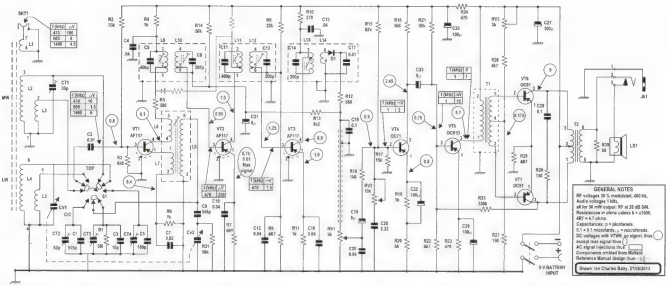


Fig.1: the Bush TR82C is a 7-transistor superheterodyne set with a push-pull audio output stage. Transistor VT1 is the converter stage, VT2 & VT3 are IF amplifier stages and VT4-VT7 form the audio amplifier with T1 acting as a phase-splitter. Switch S1 selects between the AM broadcast band and the long-wave (LW) band.

The TR82C's volume, wave-change and on-off/tone controls sit in a recessed well at the top of the case. A large dial "wheel" on the front of the set is used for tuning and is easy to operate.

the appearance of bright red anodising on the tuning scale.

In summary, in the design and usability race, the Bush TR82C is the clear winner over Raytheon's T-2500.

Design basics

Like the Raytheon T-2500, the Bush TR82C uses a conventional metal chassis. It's made from aluminium and is fitted with insulated mounting pins for the transistors (somewhat reminiscent of valve sockets). The transistors are mounted on the rear side of the chassis, allowing easy access to measure pin voltages. It also makes it easy to desolder and replace individual transistors.

On the design front, the TR82C uses a fairly conventional front-end: a self-oscillating mixer (converter) followed by two IF stages and a diode detector which also applies AGC to the first IF stage. By contrast, some competing designs (including Mullard's 1960 proposal) employed an auxiliary AGC diode to reduce converter gain on very strong signals.

This refinement is absent on the TR82C, so it was interesting to see how it handled strong signals (see "Performance" section below).

Circuit description

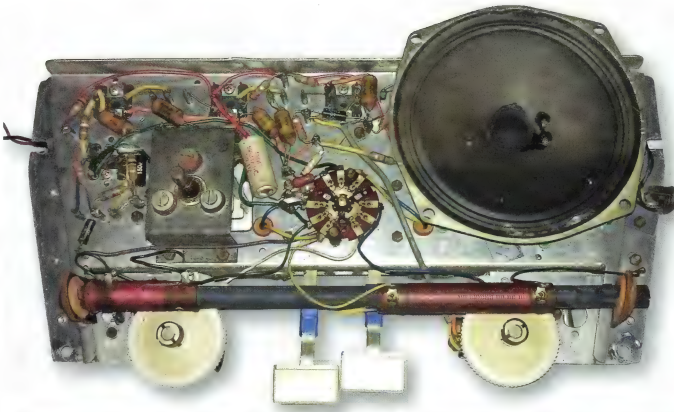
Fig.1 shows the circuit details. The Bush TR82C is a 2-band set covering both medium-wave (MW) and long-wave (LW) frequencies. These bands are selected using a somewhat unusual inductor/capacitor switching method.

The tuning gang (CV1, CV2) uses identical sections for the aerial and local oscillator (LO) circuits. Note that many single-band sets use a simplified LO section without a padder capacitor. However, this is impractical with a multi-band set such as the TR82C, as the LO would not track on any band other than the MW (broadcast) band.

For MW, both tuned sections of the ferrite rod antenna (L2, L4) are in parallel. This gives better signal coupling but yields a total inductance lower than either section alone.

The MW antenna trimmer (CT1) is permanently connected across the MW tuned winding (L2), while the tuning gang's antenna section (CV1) is wired across the LW tuned winding. When the LW band is selected, the MW tuned winding is disconnected and the LW winding (L4) only (still with the tuning gang connected) is used. In addition, the LW antenna trimmer (CT4) and shunt capacitor C5 are also now switched into circuit.

S1 switches the input to the converter between the two low-impedance



This view shows the speaker (front) side of the chassis. Note the large ferrite rod antenna and the point-to-point wiring method used (ie, no PCB). All the parts are easy to access.

antenna windings, depending on the band selected, ie, winding L3 for MW and winding L5 on LW.

The LO uses a single coil assembly, with L6 acting as the primary, L7 providing feedback and L8 used with CV2 for tuning. This means that a single adjustment affects the low-frequency end of both bands.

Basically, the designers have relied on correct alignment for the MW band, with padding and shunting capacitors added to correct for the LW band. For MW, a 556pF padder (C9) ensures correct LO tracking over the 995-2075kHz range, ie, a consistent 470kHz (the IF) above the MW band's range of 525-1605kHz. The trimmer capacitor is CT3, with C3 in parallel.

Alternatively, when the LW band is selected, shunt capacitor C1 (515pF) restricts the LO range to about 528-650kHz, ie, 470kHz above the 158-280kHz LW band.

Self-oscillating mixer

Transistor VT1 is basically configured as a self-oscillating mixer. This is an AF117 transistor and uses collector-emitter feedback, thereby reducing radiation from the LO.

As mentioned, the intermediate frequency (IF) section operates at 470kHz which is slightly more than the customary 455kHz. The IF section begins with IF transformer L9/L10 which has tapped and tuned primary and secondary windings.

Transistor VT2 is the first IF amplifier stage. This is another AF117 and is biased via the AGC circuit, with R14 supplying a bias current. The rectified output from diode detector D1 (an OA90) "bucks" the bias (via R12 & R13) with an opposing positive voltage that increases with increasing signal strength.

This AGC voltage changes the base bias and hence the current gain of VT2, thereby helping to maintain near-constant volume regardless of the signal strength.

The second IF transformer (L11/L12) also uses tapped and tuned primary and secondary windings. This in turn feeds the second IF amplifier which is based on transistor VT3, the set's third AF117. This stage operates with fixed bias for maximum, constant gain.

Note that neither IF transistor uses neutralisation/unilateralisation to combat the effects of collector-base feedback (Miller Effect). This is quite low in alloy-diffused transistors and gives no problems at low radio frequencies (such as 455-470kHz).

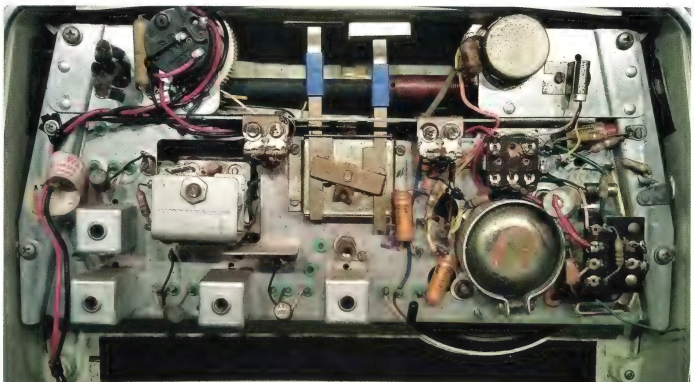
The third IF transformer (L13/L14) has a tuned, tapped primary and an untuned, untapped secondary. This secondary winding matches the low impedance of the detector diode (D1).

Thus far, the design is similar to the Mk.1 version, except that the Mk.1 used lower-performing alloy-junction transistor types, ie, OC44/OC45. However, these did require neutralisation networks for proper operation.

Audio stages

The audio section in the earlier Mk.1 version was unusual, with the first two stages being direct-coupled. It achieved good thermal stability and dispensed with one coupling capacitor, thereby improving low-frequency response.

The Mk.1 set also used an unusual "local" feedback scheme in the Class-B output stage. This involved using two extra windings on the output transformer, one for each emitter connection, with the resulting feedback reducing distortion in the output stage.



This is the view inside the set with the back cover removed. Note that the transistors are all mounted on this side of the chassis, with their leads terminated on insulated solder pins, making it easy to desolder and replace them if necessary. The method of construction used is reminiscent of that used for valve sets.

By contrast, the TR82C Mk.2 circuit ditches the direct-coupled audio preamplifier stages and reverts to the more common 2-stage configuration with resistance-capacitance coupling.

As shown on Fig.1, the detected signal from D1 is fed to volume control (RV1) and from there to the first audio stage (VT4, OC71) via capacitor C19 (8µF). Tone control RV2, connected to the base of VT4, applies adjustable "top cut" to this audio signal. This tone control also integrates the power switch, unusually switching both positive and negative battery leads.

VT4 in turn drives the second audio stage (VT5, OC81D). This transistor operates with a collector current of about 2mA and only dissipates about 20mW, yet it is mounted in a clip heatsink. This heatsink would appear to be unnecessary and may be there simply to provide a convenient way of anchoring the transistor in place.

Transistor VT5 drives the primary of transformer T1 which operates as a phase splitter. Its centre-tapped secondary then drives a push-pull output stage based on transistors VT6 & VT7 (both OC81D) and these in turn drive the centre-tapped primary winding of speaker transformer T2. T2's secondary then drives the speaker or a set of headphones (or an external speaker) via a headphone socket.

Unlike the Mk.1 version, the TR82C Mk.2 includes trimpot RV3 to allow the output stage bias to be adjusted to minimise crossover distortion. It also includes a common emitter resistor (R28) to provide a small amount of feedback. The Mk.2 version also provides a feedback loop from the collector of output transistor VT7 to the base of driver stage VT5, ie, via R25. This feedback further reduces the audio distortion.

The output power is quoted as 325mW at 10% distortion. It's fairly modest but enough to provide comfortable listening levels.

Cleaning up

Despite its age, the chassis was still in good condition and was operating normally. All that was required was a quick touch up of the alignment adjustments. During this process, I discovered that both aerial trimmers needed extra capacitance for optimum performance and I ended up adding a 10pF capacitor in parallel with each one.

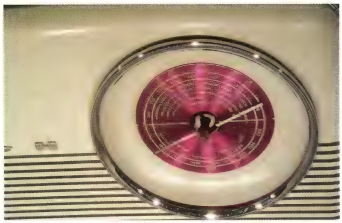
As obtained, the set also needed a good clean, both inside and out. I began this process by first dismantling the case, separating the front and back covers and the central section.

These two covers were in good shape physically but were grubby and had dirt lodged on the bottom lands of the grilles. A little "elbow-work" with some widow cleaner and a toothbrush soon had them sparkling again. The dial well was also grubby and this responded to a careful once-over with a cream cleanser.

In addition, the chrome bands were covered in some form of hardened grease/dirt composite. They were cleaned up with some judicious scrubbing and came up looking like new.

Unfortunately, the cabinet's blue middle section was a different matter. It was covered with some kind of brown, greasy film (probably from a kitchen) that proved to be quite stubborn to shift. After using a sponge wetted with a liquid kitchen cleaner to little effect, I tried using to a microfibre pad. This had proved to be effective in the past for removing all kinds of accumulations, including marker pens and paint.

It did a reasonable job but the blue colouring gradually built up on the



The photo at left shows the appearance of the bright red dial scale after the tuning wheel had been removed, so that the chassis could be removed from the cabinet. The rear cover is removed by undoing a single screw.

pad, showing that part of the plastic surface was coming off with the grease. Rather than wreck it, I didn't push my luck too far and left it before I was really happy with it.

Performance

The audio frequency response from the volume control to the loudspeaker is 170Hz to 12kHz but the RF/IF section crops the upper frequency limit to just 2.2kHz. A measured selectivity figure of -60dB at ±13kHz confirms this narrow RF/IF bandwidth, a result of the two double-tuned IF transformers

The audio performance is quite good: at 10mW output, the total harmonic distortion (THD) is 1.6% at 1kHz. This falls to 1.1% at 50mW, implying some crossover distortion or transistor mismatch at very low levels. At 250mW, the THD is just 1.7% and the set easily bettered its 10% quoted distortion at full output, giving just under 5% at 325mW.

The sensitivity is outstanding, the set delivering 50mW output (for a 20dB signal-to-noise ratio) for an RF input of just 7.5µV at the aerial terminal. Note that this is with the volume control "backed off" to give the 20dB noise figure. At full volume, this set needs just 1.5µV at 600kHz and 2.5µV at 1400kHz for 50mW.

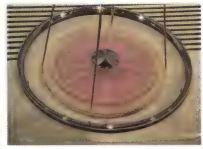
It's pretty noisy at full gain though, with a signal-to-noise ratio of just 3dB at 600kHz and 8dB at 1400kHz. Its long-wave performance is quite impressive – a sensitivity of 2.5µV for a 20dB signal-to-noise ratio approaches the 1µV "gold standard" for valve sets using RF stages.

The signal strength received by the ferrite rod antenna needs to be around 100µV/m at 600kHz and 80µV/m at 1400kHz for an output of 50µW and a 20dB signal-to-nose ratio. At full volume, the sensitivity is around 20µV/m. These measured values closely agree with the figure in the original 1960 Mullard design paper.

The "noisiness" at full gain justifies the claim that converter noise is a limiting factor in weak-signal performance for superhets of all kinds.

The AGC control is excellent for moderate signals, with a 30dB increase in signal giving just a 6dB increase in output power. The set does, however, go into RF/IF overload for signals over about 20mV/m. This is confirmed by the collector current for the first IF amplifier stage (VT2) falling to near zero at this point. The Mullard design's additional damping diode and two resistors (shown in dotted lines on Fig.1) would reduce (or prevent) this problem.

Removing The Tuning Knob



The TR82C's tuning knob is a press fit onto the tuning gang shaft and Bush's servicing manual recommends using a suction cup to pull the knob off. It also clearly advises against attempting to apply pressure using "screwdrivers or other levers'.

Another method is to wrap three or four lengths of string around the centre boss to form a simple "puller" arrangement. The above photo shows how this is done.

Would I buy another?

Given the opportunity, would I buy another one? The answer is "yes".

In fact, there's also an FM/MW/LW version, the Bush VTR103, which I've ordered. It uses the same stylish case as the TR82C Mk.2 and an equally impressive circuit design, so I expect it to also be a good performer. There's also a quite rare version that uses a miniature valve as the converter and transistors for the IF and audio stages.

Yet another version, the TR82D, is identical to the TR82C except that it has a different cabinet colour. My TR82C has a light olive-green front and back, with a blue intermediate band and a cream handle. By contrast, the TR82D is cream with a tan band.

Resurrection

Finally, the Bush TR82C's classic look has just been revived with the release of the Bush TR82DAB, a modern DAB+/FM/AM/LW radio. The TR82DAB's cabinet looks virtually identical to the earlier 1960s design and a full review appears elsewhere in this issue.

Further Reading

(1) There are several discussion threads on: http://www.vintage-radio.com/
(2) For a company history and listing of sets: http://www.bushradio.co.uk/
(3) The original service data is available (along with many other UK sets) at: http://www.service-data.com/ SC

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WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
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ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Questions regarding a PIC digital tachometer

One of my brothers wired a digital tachometer (that had been sitting around unused for a long time) into our boat which has a 1970 V8 petrol engine. From web searches, the tacho appears to be a Jaycar KC-5290; the PCB itself has 05104001 on it.

A 10Ω resistor in it has blown which I can see is the first component to be connected to the positive supply. I suspect that the resistor may have been rubbing on the capacitor beside it and if there is an earthed connection there, that would explain the failure.

Jaycar do not appear to sell this kit anymore and we do not have a wiring/circuit diagram. Which leads to a problem – unfortunately there are two black, two red and one green external connection wires. The positive and negative connections are easy to determine as they are marked on the board.

My brother who installed it thought the other connections were just chosen based on how many cylinders the vehicle has. From a previous SILICON CHIP question, it appears that this unit may have connections for digital tachometer output and ignition coil output. Are you able to supply information on this and the connections?

Lastly, what is the power supply voltage range that this unit will safely run on? (M. K., via email).

● This project was published in the August 2000 issue of SILICON CHIP. We can supply a copy of this issue if you need it. Go to http://www.siliconchip.com.au/Shop/2

The 10Ω resistor may have blown if zener diode ZD1 is installed the wrong way (cathode is the striped end) or if the unit was connected to more than 16V DC. The tacho is suited for 12V DC, ie, up to 15V from a 12V battery.

The wire near pin 4 of the LM358 is the low input to the tacho and is used when there is a 5V tacho signal available. The wire to the 22kΩ resistor is for the ignition coil negative connection when the low voltage signal is unavailable. The wire from the right of the 7-way socket is a limiter output signal.

Setting up for an 8-cylinder engine is done using the switches and you would need to read the article for the procedure.

Photovoltaic panels for solar hot water

With all the discussion about electric hot water cylinders, solar hot water systems, grid-connected solar panels, and the fact that my mains pressure HW cylinder is 22 years old, I investigated some options. Solar hot water panels with a cylinder that has a stainless tank and where the water from the panels circulates in a jacket around the tank seemed a good solution until I priced it. A gas instant hot water system seems a good option as well but still expensive.

I then spoke to a local installer of alternative power systems who suggested this option: connect 10 200W 24V solar panels in series (giving 240V DC), provide a suitable switching system to control the panel output and enable the AC mains supply to be used in an emergency.

My question: is this too simplistic

Bass From Headphone Amplifier Seems Light On

I built the Hifi Stereo Headphone Amplifier described in SILICON CHIP, September 2011 but it is a bit light on in the bass region. Do you have any suggestions?

I checked the capacitors in the input area of the circuit and the values and polarities are correct so is this intrinsic with this unit? I've also recently purchased a Sony AV receiver and most of the time at switch on there's one hell of a thump from the receiver but not in the headphones. Is this normal?

The SILICON CHIP Headphone Amplifier's audio quality is far superior to the Sennheiser amplifier and the Sony AV receiver and both were very expensive too. Do you think you will ever publish a coaxial input headphone amplifier? (D. S., via email).

● The frequency response of the headphone amplifier is flat to well below 10Hz which is so low that it is infrasonic (inaudible). If your headphones have more bass with other amplifiers then they have some artificial boost and they are probably not as distortion-free.

Note that the sound quality in stereo mode will always be cleaner than any setting in surround sound. Surround sound processing messes the signal up too much and it is gimmicky anyway.

On the question of turn-on thumps, well-designed equipment should have no turn-on thump when driving speakers or headphones. If your Sony receiver does this, possibly it is because you are switching it on at the wall, rather than its front panel switch or via its remote control.

As far as a high-quality coaxial input (S/PDIF) headphone amplifier is concerned, our CLASSiC DAC project in the February & March 2012 issues fits that description but its internal headphone amplifier is not quite as good as the Hifi Stereo Headphone Amplifier which you built.

So for ultimate sound quality, these two projects could be combined. However, that would be large and complex project involving a lot of very tiny surface-mount components which can be difficult and time-consuming to solder.

and is he missing something? The open circuit voltage of the panels could be in the order of 350V so some form of load would be required when the cylinder is up to temperature and the element switched off and because it is DC source, a standard thermostat would not be suitable. I would be interested in feedback from others on this matter as it seems a simple solution. 24 200W panels are about $320.00 NZ dollars each. (H. R., Taranaki, NZ).

● There would appear to be several problems with the solar panel approach, superficially attractive that it is. First, the panels will be delivering around 34-36V each when optimally loaded. That means about 350VDC @ 6.8A (for 2400W) and that means the optimum load would be a resistance of about 50Ω. However, your hot-water tank is likely to be rated at 3600W and have a heater resistance of 16Ω or thereabouts – a big mismatch.

You could get a better match by arranging the panels in two parallel groups of five, giving an output of about 175V at 13.7A (for 2400W). This means the optimum load would be a resistance of about 13Ω which is much closer to the tank's heater resistance so that could be workable.

However, you would need to investigate the ratings of the thermostat to see if it could reliably switch 175V DC (certainly more manageable than 350V DC). You would also need a DC isolator so that the tank could be switched back to the mains supply. Perhaps an isolator switch for a grid-feed solar system could be used here but the switch-over process might be a 2-step process: isolate the DC from the panels then use an AC circuit breaker to connect the mains supply.

Of course, this would all have to be done by your electrician to make sure that the whole installation was safe. Note also that the DC supply approach may cause corrosion in the heating element unless the polarity was changed periodically.

Voltage regulator for a micro hydro plant

I have just finished setting up a micro hydro plant. I am looking to build a regulator to maintain the charging instead of the way I do it now which is simply turning the water on and off.

It is a 48V system. Ideally, I would like to turn on a heating element when the batteries reach around 56V and turn off at, say, 53V. I was considering using the Alternative Power Regulator (SILICON CHIP, June 2005).

My question is do you know where the kit is available from and what would need to be done to convert it to 48V operation? (G. C., Reefton, NZ).

● This shunt regulator circuit was designed and supplied by Oatley Electronics (www.oatleyelectronics.com) and you would have to check with them to see if the kit is still available. You should be able to run it from 48V by changing the 120kΩ and 22kΩ resistors that are provided for 24V operation to 426kΩ total (using 390kΩ and 36kΩ). The Mosfets (Q5-Q9) should be changed to 100V types.

The 2N5551 transistors are 160V so they should be OK except for Q1, as this should be changed to a higher wattage type such as a BD139 to allow for about 500mW power dissipation when regulating from 48V.

Concern About Car Battery Drain

What is considered an acceptable current drain from a car battery when it is parked or switched off? What if the car has a radio (memory for stations), car alarm and ignition killer relay? My own car seems to have a current drain of around 150mA when parked and the ignition is off. (N. D., via email).

● The amount of standby current drain that can be tolerated depends on the battery capacity and whether you can maintain battery charge by driving the vehicle before the battery becomes so discharged that the engine cannot be restarted.

As a rough guide, divide the 150mA into the amp-hour (Ah) battery capacity to find the number of hours the battery can deliver this current before discharge. Most car batteries are rated for cold cranking capacity and reserve capacity (RC). The cold cranking value cannot be directly converted to Ah capacity. The reserve capacity is specified in minutes and specifies how many minutes the battery can deliver 25A before the battery drops to 10.5V. To convert to Ah, multiply the RC by 25 and then divide by 60 to convert from minutes to hours.

Typically, the Ah value for low current draw will be greater than this since the RC is based on a 25A discharge and not at 150mA. However, it is best to be conservative in the Ah estimation so the battery will have sufficient capacity to start the engine.

So, for example, a small 4-cylinder engine vehicle might have a battery that has an RC of 55 minutes and the Ah conversion gives about 23Ah. At 150mA drain, the battery will discharge in about 152 hours or just over six days. We consider that period to be too short and would prefer the battery to be capable of maintaining its charge over several weeks.

If you do not drive the vehicle often, then consider using a battery charger to maintain charge using mains or solar power. Alternatively, you can find the cause of the excess current draw and have it switched off via the ignition.

For your vehicle, the ignition killer relay might be a cause of the high current and may well be powered with the ignition off. Further current drain will be due to the alarm and vehicle radio/CD/MP3 player which has a standby current to maintain its memory settings. These players can be wired in one of two ways. One wiring option has just the memory connected to a permanent 12V supply and the main supply for the player connected to the ignition (switched) 12V. That way, only the memory draws standby power.

Another option is to have the main power for the player powered from a permanent 12V supply so that the player can be used any time, ignition on or off. This has the greater standby current drain because the player is then switched on and off by its own switch. This switching is usually not just a power switch but just wakes up the player when pressed and puts it to sleep when pressed again to switch it off. When off, the sleep current maintains power to the switch-on circuitry.

Fault-finding the Digital Spirit Level

I recently needed a device to measure angles and lo and behold SILICON CHIP had described a Digital Spirit

Digital Lighting Controller Refuses To Operate

I've been building the Digital Lighting Controller Master Unit as described in the October 2010 issue of SILICON CHIP, along with four LED slave units from the October 2011 issue. I have about 4000 LEDs prepared in a giant Christmas tree ready to run with the system for a great display.

In testing the Master unit, on power-up the LED flashes twice but fails to pulsate (as per the test procedure) or turn on if a loaded SD card is present with music files present.

I've checked the zero-crossing circuits and measured a 0.72VAC signal across pins 4 & 5 of IC1 and 1.65V DC on pin 4 and 0VDC on pin 5 referenced to ground. The LED on the master unit doesn't light at all after the initial two flashes and hence it doesn't display the flash sequence for the various fault codes. What should my next step be? Replace the 24.576MHz crystal or the dsPIC micro? Anything else I could have damaged? (N. W., via email).

● Does the controller pulsate without an SD card? If so, then the micro is probably OK but there may be some kind of incompatibility with the SD card you are using.

We have tested it with a number of cards but there may be some that it still has problems with. If it doesn't pulsate when you leave the SD card out, it's probably a hardware fault. Another constructor had a similar problem to you and it turned out to be a faulty 24.576MHz crystal. Try replacing that and see if that fixes the problem.

The unit runs from its internal 7.37MHz oscillator while the bootloader is active (when the LED flashes twice) and then switches to the crystal+PLL after that. If the crystal is faulty, it will freeze at that stage. We also had a couple of people with bad 10µF tantalum capacitors (high ESR) although in that case, the LED flashed constantly since the micro was continuously rebooting when it tried to enable the PLL, after the bootloader had finished.

By the way, there was a bug in the original firmware which prevented the unit from working properly with four slaves. You can either reflash the microcontroller with the latest code (eg, using the SD card bootloader) which is available for download at our website or you can pull the sense resistor out of one of the slaves (the bug had to do with it incorrectly counting the number of sense resistors).

Level in August 2011. Unfortunately, when powered up, it did not work.

After a quick inspection I found that I had fitted a 10Ω resistor instead of 10kΩ from the +3V rail to pin 4 of IC2. I rectified this and tried it again. I got one quick red flash on the display then nothing else. Switching power on and off did not give another red flash, however leaving it off overnight, then switching on did give a red flash. I have checked a range of voltages.

I have found no voltage drop across the two 4.7kΩ resistors and there is no discernible voltage on either end of any of the 4.7Ω resistors. Since there is no display, this may be normal. From the above, can you advise whether IC2 is damaged or has lost its memory or is IC1 not really connected? I would have thought that maybe the display would give some output even if IC1 was open circuit. Your assistance in this matter would be greatly appreciated. (D. F., Cecil Hills, NSW).

● It is unlikely the 10Ω resistor to pin 4 of IC2 will have caused damage in the short term. Check for 3V between ground and pins 1 & 14 of IC1 and pins 1 & 4 of IC2. If these are OK, check the soldering around IC1. Any broken connection or short between IC1s pins will prevent it from working.

Also check the connections between IC1 and IC2. In particular, check between pin 11 of IC1 and pin 18 of IC2. You should get a 1kΩ reading between these two pins.

The display shouldn't show until the accelerometer chip signals a movement, waking IC2 from sleep. So if IC1 is not connected properly, there will be no display.

LED Strobe & Tacho crystal query

With reference to the LED Strobe & Tachometer circuit in the August 2008 issue, can you confirm that the crystal capacitors are going to 5V, as I thought they would be grounded? (A. D., via email).

● Yes, the crystal capacitors are tied to the +5V rail rather than more conventionally to the 0V (ground) supply rail. This was done to simplify the PCB layout.

They are effectively still grounded due to the 5V supply decoupling capacitors connecting the +5V rail to ground for AC signals. So as far as the oscillator circuit is concerned, the capacitors are still effectively grounded and the 5V DC does not couple into this circuitry as it is blocked by the capacitors.

Signal overload on USB DTV dongles

I notice that Jim Rowe has been writing a series of articles about USB DTV dongles. I have various PCI, USB Tiny Twin and other dongles. However, none of the newer ones will tune in any channels using a high-gain array and amplifier. All older dongles work fine. One of the newer dongles is even nominally the same as an older one.

Am I missing some salient point? Has Jim been able to get any of these models to work? (A. G., via email).

● We haven't tried any of those dongles. Since they may have the Raphael Micro R820T tuner chips fitted, perhaps this chip is overloaded when presented with high-level signals. In fact, it sounds like this might be happening because you are using a high-gain antenna array together with a masthead amplifier.

USB DVB dongles & Windows 7 64-bit

I read with interest your articles on DVB dongles and DAB in the April and May 2013 editions so I decided to try one out. The item I purchased was only $6 at the time. It's now $8.49 but still cheap. It's a very neat package and only uses a single chip (IT9135FN). It also came with an IR remote control.

I fired it up on a Windows XP system and it works well with the included BlazeVideo program. I used the included whip antenna and it only found

ABC, SBS and C31 stations, including associated audio programs, and all worked well. If I used a real antenna I am sure all other stations would come in strong.

I have sent you an attached photo and data sheet for the IT9130. It tunes from 170MHz ~ 240MHz in the VHF band and 470MHz ~ 862MHz in the UHF band.

I then decided to migrate it to my new Windows 7 64-bit laptop but BlazeVideo hangs badly when it was asked to scan channels. It required a reboot to exit the program. Ctrl-Alt-Del would not close the program. Have you had any experience with the Win7/64-bit environment? (P. K., Dromana, Vic).

● Jim Rowe did try Blaze Video on a Win7/64-bit machine and it worked fine, although the USB driver had to be installed as the Administrator or it wouldn't install properly.

By the way, the chip in your dongle doesn't appear to offer FM reception and as a result it may not be suitable for use as an SDR front-end. It also seems to have a much more limited frequency range.

SDR chip needs correct dongle

I bought your May 2013 issue, hoping to install the SDR program with my Dazzle 71e USB dongle on my Windows XP machine. Inside the dongle is a chip with AF9015 written on it; probably the USB interface chip. I think the demodulator chip is in the metallic can so I can't open it.

Zadig installed the driver successfully according to the message dialog and it appeared in the driver properties details as indicated in your magazine. Everything installed OK but when I select USB dongle in the SDR program to start configuration, it says USB driver not installed or not working. I have installed the recommended USB driver as indicated in the magazine first. However, I am not sure which one so I used WinUSB.

I hope you can give me some ideas as to what went wrong or if my USB dongle is incompatible. (F. K., via email).

● We're not familiar with the DVB-T dongle you are using, so it's not possible to say whether it is compatible with the RTL-SDR driver or SDR software like SDR#. Have you tried opening it up, to check if it uses the Realtek RTL2832U demodulator chip? This chip is more or less necessary if the dongle is to be compatible with the SDR driver and software.

Faulty Drive On Studio Series Remote Module

I purchased the Studio Series Remote Control Module from Altronics. The channel switching works fine and it has been paired effectively with a remote control unit. Unfortunately though, the motorised volume pot does not operate from the board.

I tested the pot and it works with 3V up and down (recommended voltage is 4.5V), manually changing polarity. It is an ALPS remote pot. When I removed the motor plug from the board, the output only measures 1.23V when the UP/DWN button on the remote control is pressed. Is this likely to be because of faulty bridge transistors? (A. D., via email).

● The transistors could be faulty (unlikely) or they could be transposed; BC327 for BC337 on the PCB or the base resistors are incorrect (they should be 1kΩ).

In operation, PD5 & PD2 will be high (5V) and PD3 & PD4 will be low (0V) with the motor off. When the motor is running, PD5 will go low and PD3 will go high for one motor direction and PD2 will go low and PD4 will be high for the opposite direction. Check these and check that the associated transistors are switching on.

In other words, the collectors of Q1 & Q2 will be high and the collectors of Q3 & Q4 will be low for one direction, while the collectors of Q1 & Q2 will be low and the collectors of Q3 & Q4 will be high for the other direction.

Also, make sure that VR1 is adjusted clockwise initially so that the motor can run. Then adjust it back for it to stop when end of travel is reached.

Problems with lunatic geese

Will your Barking Dog Blaster (SILICON CHIP, September 2012) stop raving lunatic geese? I am being driven mad by them. (J. B., via email).

● It will stop raving lunatic geese but only if they are barking mad.

Seriously, this type of ultrasonic deterrent simply does not work with birds of any species, let alone barking or honking geese. A far better deterrent may be to build and use a potato gun but bear in mind that if you do, you may get complaints from your neighbours and a visit from your friendly local constable.

Questions on the 12V stereo amplifier

I am interested in utilising the 12V stereo amplifier (SILICON CHIP, May 2010). I have the article on the project but I am not sure about the required input signal level range. I intend to use a normal microphone that swings around 30-150mV, as well as other adjustable audio input levels up to 500mV on the other channel. The data says 500mV for 10W into 8Ω. I understand that the input can be smaller at 4Ω.

I also don't know the PCB dimensions as I will not be using the case supplied. Can you advise on these issues please? (I. F., via email).

● Input sensitivity for a 4Ω load is half that for an 8Ω load so it would be 250mV RMS for 10W into a 4-ohm load. Thus you could probably get away with a direct microphone connection but you wouldn't be able to get full output power. That may not matter, depending on your speaker efficiency.

Depending on the type of microphone, you may need to increase the unit's input impedance to avoid loading it too badly. This can be done by using a higher-value pot and replacing the 100kΩ resistors with a higher value too (1MΩ or above). That will increase noise a bit but probably not to an unacceptable level.

We have published a number of microphone preamps (eg, in the July 2008 and September 2010 issues) and if you connect one of these between your microphone and the 12V stereo amplifier that will allow you to adjust the gain to get full power output from the amplifier. The September 2010 design should run off 12V without modifications. The July 2008 design is designed to run off 5V and may require a regulator.

Phantom-Powered Mic For USB Recording Interface

I am interested in using your USB Stereo Recording & Playback Interface (SILICON CHIP, June 2011) for testing loudspeakers. I was planning on using a calibrated microphone such as the Dayton EMM-6 – see www.daytonaudio.com/media/resources/390-801-dayton-audio-emm-6-specifications-46337.pdf

I was wondering if the mic inputs in this project have a suitable level of gain for this microphone. If not, what modifications would I need to make?

This mic requires phantom power and I was keen to include this in the construction. Have you published a suitable circuit or project to add phantom power supply to the mic inputs? (J. A., Newcastle, NSW).

● There should be no problem with the mic input gains of the June 2011 Recording & Playback Interface, as they have quite high maximum gain.

However providing the Dayton Audio EMM-6 mic with phantom power would be a tricky, as it needs a phantom power source of between +15V and +48V while the June 2011 interface has a supply voltage Vcc of only around 4.0V (derived from the USB link). So you'd need to provide the phantom power from an external power supply. Either that or add a very small DC-DC step-up converter to derive +15V from the Vcc rail in the Recording & Playback Interface. The step-up converter would need to be carefully shielded to prevent hash from finding its way into the interface preamps.

Whichever method you use, the easiest way to supply phantom power to the mic is to change the 100kΩ resistors connected to pins 2 & 3 of the input socket to 2.2kΩ, lift their earthy ends and connect them together to the phantom power +15V rail (or use 6.8kΩ for a 48V supply).

Note that maximum power from the 12V amplifier is obtained with a supply voltage above 12V, eg, 14.4V from a lead-acid battery under charge.

The PCB is 97 x 78mm. This is mentioned in the parts list.

Clock back-up batteries should be rechargeable

Like most rural people, we experience a lot of short-term power failures, which frequently means having to reset all the digital alarm clocks. 9V back-up batteries don't last and are expensive so I was wondering if this warrants a project to replace the backup batteries with a circuit that remains charged and solves the constant resetting of digital alarm clocks.

By the way, I can't seem to find a digital alarm clock for sale that doesn't need a back-up battery. (T. B., Lakes Entrance, NSW).

● We are not sure what you are proposing. It sounds like a back-up circuit with a rechargeable battery. That seems to be a lot of trouble to go to just to avoid replacing a 9V battery. If you use an alkaline type, it should last for quite a few years (as do smoke detector batteries). In fact, they should last for their shelf life, unless you have a lot of power failures which each last for many hours.

It may be worth seeing if you can arrange to fit a rechargeable 9V battery and have it on a low trickle charge from the clock's DC supply via a diode and a high-value resistor, say 10kΩ.

CDI for quad bike

I want to try the replacement CDI module for small petrol motors (SILICON CHIP, May 2008) on a Suzuki LT-Z50 quad bike. The article says the capacitors are AC, meaning alternating current or does AC stand for something else like Audio Capacitor etc? Has anyone made this work 100% on an engine? (J. A., Alabama, USA).

● AC refers to alternating current. These capacitors are rated for 275VAC and are used in mains (230VAC) circuits. In the USA, you can obtain these from suppliers that have European voltage X2-rated capacitors, such as Digi-Key and Mouser.

The CDI circuit does work but it does rely upon the original vehicle CDI having a high-voltage generator coil.

Measuring small AC signals

Have you ever published an article on using an ICL7107 chip in an auto-ranging digital panel meter? I need it to accurately measure 200mV AC. (G. S., Delhi, India).

We have not published anything on the ICL7107 but we did an article

continued on page 103

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

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Ask SILICON CHIP

. . . continued from page 102

on the very similar ICL7106 in the September 1992 issue. The only difference is that the 7106 is designed to drive liquid crystal displays (LCDs) while the 7107 drives 7-segment LED displays. However, the published circuit is not auto-ranging and given that you mainly want to measure 200mV, that possibly is not important.

Measuring 200mV AC depends on the nature of the signal. If the frequency is low enough (below about 100kHz) and it will always be a sinewave or square wave, then you can accurately measure its amplitude using a precision full-wave average detector circuit. This circuit can be found on page 10 of the LM3915 data sheet.

You will want to use a dual op amp with as much bandwidth as possible but note that you will need a split supply to run it, ie, positive and negative rails. It is possible to do this without a negative rail but then you need to connect the non-inverting inputs of the two op amps to half supply rather than ground. Also note that if your supply voltage is low, you will need to use rail-to-rail op amps.

If the input is a sinewave, you will also need to apply a correction for the difference between the average and RMS values of a sinewave to get an accurate reading. The RMS value of a sinewave is 11% higher than the average so you will need to change the feedback resistor value to compensate for this. Changing R5 to 220kΩ instead of 200kΩ will do the job.

If the input is not a sinewave or

continued on page 104

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Notes & Errata

1.5kW Induction Motor Speed Controller, April-May 2012, December 2012, August 2013 (see also errata June 2012):
(1) May 2012 – the thermostat mounting hole position shown on the drilling diagram (Fig.9) on page 70 of the May 2012 issue should be moved so that it is 170mm from the lefthand edge of the heatsink (not 130mm). Be sure to orientate TH2 correctly and keep its leads short so that they cannot possibly contact any high-voltage circuitry.

In addition, the mounting hole for BR1 is incorrectly positioned. It should be 45mm up from the bottom edge of the heatsink (as indicated) but is actually incorrectly positioned 40mm up from the heatsink edge.
(2) August 2013 - the article in this issue recommended changing the current-limiting resistor in series with zener diode ZD1 to 470Ω (previously 1kΩ). This 470Ω resistor should be rated at 0.5W (not 0.25W).
(3) Completely updated articles for the 1.5kW Induction Motor Speed Controller have been produced and substituted for the original articles on our website: **www.siliconchip.com.au** These articles incorporate all modifications (including the above errata) to the unit which now uses a modified PCB (10105122) and revised software for the microcontroller (1010512B.hex).

CLASSiC DAC, February-May 2013: two capacitors were left off the DAC output filter diagram (February 2013, p25) and the circuit diagram (March 2013, p22). These 6.8nF capacitors connect between the junction of the two 1.5kΩ resistors and ground. They were included on the PCB layout diagram (April 2013, p39) and in the parts list (the PCB is correct).

Ask SILICON CHIP
. . . continued from page 103

square wave and you want an accurate measurement, then you need an IC designed for making true RMS measurements, such as the AD536, AD736 or AD737.

As for auto-ranging, digital multimeters use custom ICs that do all this work including the ADC, true RMS calculations (if present), display driving and auto-ranging. While you could do this yourself using discrete parts, the easiest way will be to program a microcontroller to do the auto-ranging.

First, you need a way to scale the signal in a variable manner. There are a few ways to do this – you can use a programmable gain amplifier (PGA), you can build dividers with different ratios (1:1, 10:1, 100:1) and then use an analog switch/multiplexer (eg, 4051B) to switch one of them at a time to the input of your ADC/true RMS chip, or you can have a single divider with a variable ratio, based on a number of resistors and Mosfets.

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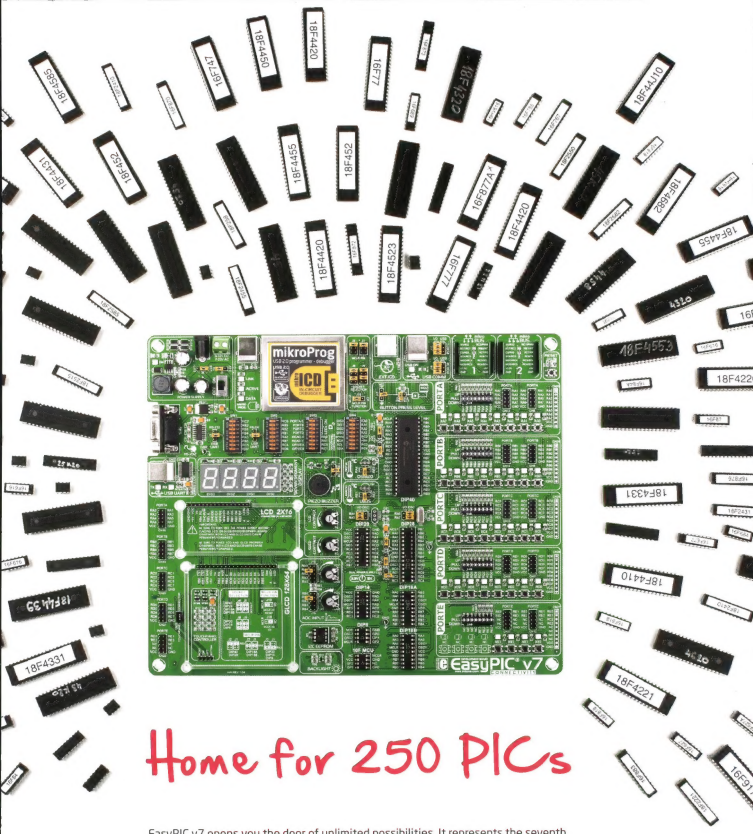
Once you have the ability to scale the input to your ADC, it's then just a matter of programming the microcontroller to monitor the analog voltage being fed to the ADC and switch up/down in range depending on whether it is above or below a certain voltage threshold. SC

Advertising Index

Advantage Partnership Lawyers	103
Altronics	9,74-77
Emona Instruments	63
Front Panel Express	13
Hare & Forbes	OBC
Icom Australia	5
Instant PCBs	103
Jaycar	IFC,49-56
Keith Rippon	103
KitStop	13
LED Sales	103
Low Energy Developments	103
Master Instruments	7
Microchip Technology	21
Mikroelektronika	IBC
Ocean Controls	39
Quest Electronics	103
Radio, TV & Hobbies DVD	85
RF Modules	104
Rixen Pedals	69
Rohde & Schwarz	3
Sesame Electronics	103
Silicon Chip Binders	78,87
Silicon Chip Bookshop	57
Silicon Chip Online Shop	96-97
Silicon Chip Subscriptions	27
Tekmark Australia	8,12
Wiltronics	11
Worldwide Elect. Components	104
xLogic	12



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